Chapter 11

Defining Reservoir Operations Data

Table of Contents

Section **Page**

11 Defining Reservoir Operations Data
11.1 Reservoir Editor's Operations Tab 11-2
11.2 Reservoir Operation Sets 11-3
11.2.1 Creating a New Operation Set 11-3
11.2.2 Renaming an Operation Set 11-4
11.2.3 Copying an Operation Set 11-5
11.2.4 Deleting an Operation Set 11-5
11.2.5 Editing an Operation Set 11-6
11.3 Reservoir Operation Zones 11-6
11.3.1 Renaming and Describing Operation Zones 11-7
11.3.2 Adding a New Reservoir Storage Zone 11-7
11.3.3 Defining Operation Zones 11-8
11.3.4 Deleting Operation Zones 11-9
11.4 Understanding Reservoir Operation Rules 11-10
11.4.1 Release Decision Process 11-10
11.4.2 Using Existing Rules 11-11
11.4.3 Removing Rules 11-11
11.4.4 Deleting Rules 11-11
11.4.5 Prioritizing Rules 11-11
11.4.6 Renaming Rules 11-11
11.5 Defining Reservoir Operation Rules 11-12
11.5.1 Adding a New Operation Rule to a Zone 11-13
11.5.2 Adding an Existing Rule to a Zone 11-14
11.5.3 Defining a Release Function Rule 11-14
11.5.4 Defining a Downstream Control Function Rule 11-19
11.5.5 Defining a Tandem Operation Rule 11-21
11.5.6 Defining an Induced Surcharge Rule 11-22
11.5.7 Defining a Flow Rate of Change Limit Rule 11-26
11.5.8 Defining an Elevation Rate of Change Limit Rule 11-27
11.5.9 Defining Hydropower Rules 11-29
11.5.9.1 Hydropower – Schedule 11-29
11.5.9.2 Hydropower – Time Series Requirement 11-30
11.5.9.3 Hydropower – Power Guide Curve 11-31
11.5.9.4 Hour of Day Weighting Factors 11-33
11.5.9.5 Day of Week Weighting Factors 11-34

Section (continued) **Page**

11.6 Common Options for Rule Definition 11-35
11.6.1 Interpolation Method 11-35
11.6.2 Hour of Day Multiplier 11-37
11.6.3 Day of Week Multiplier 11-38
11.6.4 Rising / Falling Condition 11-39
11.6.5 Seasonal Variation 11-40
11.7 Editing the Reservoir Decision Interval 11-41
11.8 Selecting the Reservoir Guide Curve 11-42
11.9 Adjusting the Guide Curve for Flood Control Credit Storage 11-43

List of Figures

Figure Number **Page**

11.1 Reservoir Editor--Operations Tab 11-2
11.2 New Operation Set Dialog Box 11-4
11.3 Rename Operation Set Dialog Box 11-4
11.4 Duplicate Operation Set 11-5
11.5 Select Operation Set to Delete 11-5
11.6 Reservoir Editor Showing New Operation Set 11-6
11.7 New Zone Dialog Box 11-7
11.8 Reservoir Editor--Operations Tab: Zone Editor 11-8
11.9 New Operating Rule Dialog Box 11-13
11.10 Select Existing Rule Dialog Box 11-14
11.11 Reservoir Editor--Operations Tab: New Release Function Rule 11-15
11.12 Reservoir Editor--Operations Tab: Release Function Rule, Selecting a Function from the Independent Variable Definition Editor 11-16
11.13 Reservoir Editor--Operations Tab: Release Function Rule, Selecting an Independent Variable from the Model Variable List 11-16
11.14 Reservoir Editor--Operations Tab: Release Function Rule, Defining an External Variable as the Independent Variable 11-17
11.15 Time Series Options for Model and External Variables 11-17
11.16 Reservoir Editor--Operations Tab: Example of Completed Release Function Rule 11-18
11.17 Reservoir Editor--New Operating Rule: Downstream Control Function 11-19
11.18 Reservoir Editor--Example of a Downstream Control Function Rule 11-20
11.19 Reservoir Editor--New Operating Rule: Tandem Operation 11-21
11.20 Reservoir Editor--Example of a Tandem Operation Rule 11-22
11.21 Reservoir Editor--Operations Tab: Create Induced Surcharge Rule 11-23
11.22 Reservoir Editor--Operations Tab: Induced Surcharge Rule 11-24
11.23 Plot of Computed Induced Surcharge Curves 11-25
11.24 Induced Surcharge--Falling Pool Options 11-25
11.25 Reservoir Editor--Operations Tab: Flow Rate of Change Limit Rule 11-27
11.26 Reservoir Editor--Operations Tab: Elevation Rate of Change Limit Rule (Pool) 11-28

List of Figures (continued)

Figure Number **Page**

11.27 Hydropower Rule Types 11-29
11.28 Hydropower – Schedule Rule Editor 11-30
11.29 Hydropower – Time Series Requirement Rule Editor 11-31
11.30 Hydropower – Power Guide Curve Rule Editor 11-32
11.31 Hour of Day Weighting with Default Values of 1.0 Specified for Entire Day 11-33
11.32 Hour of Day Weighting with Values of 1.0 Specified for Portion of Day 11-33
11.33 Hour of Day Weighting to "Double" the Power Requirement for Portion of Day 11-34
11.34 Hour of Day Weighting Modified from Default Values 11-34
11.35 Day of Week Weighting with Default Values of 1.0 for Each Day of the Week 11-34
11.36 Day of Week Weighting with Values of 0.0 for Saturday and Sunday 11-34
11.37 Day of Week Weighting to "Double" the Power Requirement on Wednesday 11-35
11.38 Day of Week Weighting Modified from Default Values 11-35
11.39 Interpolation Methods 11-35
11.40 Linear Interpolation Method 11-36
11.41 Step Interpolation Method 11-36
11.42 Cubic Interpolation Method 11-36
11.43 Hour of Day Multiplier with Default Values of 1.0 Specified for Entire Day 11-37
11.44 Hour of Day Multiplier with Values of 0.0 Specified for Portion of Day 11-37
11.45 Hour of Day Multiplier Modified from Default Values 11-37
11.46 Day of Week Multiplier with Default Factors of 1.0 Specified for Each Day of the Week 11-38
11.47 Day of Week Multiplier with Factors of 0.0 Specified for Saturday and Sunday 11-38
11.48 Day of Week Multiplier Modified from Default Values 11-38
11.49 Rising / Falling Condition Dialog Box 11-39
11.50 Rising / Falling Condition Modified from Default 11-39
11.51 Seasonal Variation Dialog Box 11-40
11.52 Reservoir Decision Interval Editor, Interval Options 11-41
11.53 Reservoir Decision Interval Editor, Regular Interval Option 11-41
11.54 Reservoir Decision Interval Editor, Weekly Schedule Option 11-41
11.55 Operations Menu, Guide Curve Option 11-42
11.56 Reservoir Guide Curve Editor 11-42
11.57 Reservoir Guide Curve Editor, Checkbox to Indicate Guide Curve is Modified by Available Flood Control Storage in Other Reservoirs 11-43

List of Figures (continued)

Figure Number **Page**

11.58 Reservoir Guide Curve Editor, Edit Reservoir Set to Select Reservoirs to Provide Flood Control Storage Credit 11-43
11.59 Reservoir Guide Curve Editor, Reservoirs to Provide Flood Control Storage Credit 11-44
11.60 Reservoir Guide Curve Editor, Definition of Function for Using Flood Control Storage Credit 11-44
11.61 Example of Reservoir Guide Curve Editor Showing Definition of Flood Control Storage Credit 11-45
11.62 Reservoir Guide Curve Editor, Available Credit Storage vs. Credit Storage 11-45
11.63 Reservoir Guide Curve Editor, Seasonal Guide Curves for Potential Credit Storage 11-45

CHAPTER 11

Defining Reservoir Operations Data

The regulation plan for most Corps reservoirs centers on a seasonally varying target pool elevation commonly called the **Guide Curve**. The storage of the reservoir above this target elevation is referred to as the **Flood Control** pool. The storage below the guide curve is called the **Conservation** pool. The guidelines for determining the release from the reservoir are then based on where the current pool elevation is in relation to the guide curve. Under basic operation, if the pool is below the guide curve, then the basic objective of the regulator is to reduce releases in order to refill the pool; if the pool is above the guide curve, then the regulator will want to increase releases to draw down the pool. Additional goals and constraints are then applied to temper such a rigid operation plan.

In a manner similar to the methods a regulator may use, each reservoir in your ResSim network must determine how much water to release at each time step of a simulation run. To make this possible, you must describe an operation plan or scheme upon which it can base its decisions. This plan is called an **Operation Set**. You can define multiple operation sets for each reservoir, but an individual alternative can follow only one operation set per reservoir.

An operation set consists of three basic features: **Zones**, **Rules,** and the identification of the **Guide Curve**.

Zones are operational subdivisions of the Reservoir Pool. Each zone is defined by a curve describing the top of the zone. When you create an operation set, ResSim establishes a default set of zones within the operation set. These zones are **Flood Control**, **Conservation**, and **Inactive**. The ***Inactive*** zone is a special zone in the operation set. It represents the "dead" storage of the reservoir. The reservoir cannot release water from the Inactive pool, and rules cannot be added to this zone.

Rules represent the goals and constraints upon the release(s). Rules can be applied to selected zones of the reservoir to describe the different factors influencing the release decision when the reservoir elevation is within each zone.

The guide curve concept is used as the basis for the release decision process in ResSim. Basic Guide Curve operation means "get the reservoir pool elevation to the current guide curve elevation as fast as possible, within the physical and operational constraints of the outlets".

The **Guide Curve** is identified by selecting the top of one of your operational zones to represent the target elevation of the reservoir. By default, ResSim assigns the Guide Curve to the top of the **Conservation** zone.

> *An operation set that has the zones defined but no rules will cause ResSim to follow the Basic Guide Curve operation. For testing purposes, every reservoir should have an operation set of this type. It is the easiest way to verify that your physical data, your operational zones, and your guide curve have been properly defined.*

This chapter will guide you through the process of defining operations data for your reservoir network. The first section describes key features of the **Operations** tab you will need to recognize. The remainder of the chapter explains how to create an Operation Set, define Zones, define Rules, and select your Guide Curve.

11.1 Reservoir Editor's Operations Tab

Using the **Operations Tree**, the **Edit Panel**, and the **Operations**, **Zone**, and **Rule** menus, the Operations tab of the Reservoir Editor (Figure 11.1) allows you to define operation sets and their zones and rules for the reservoirs in your network.

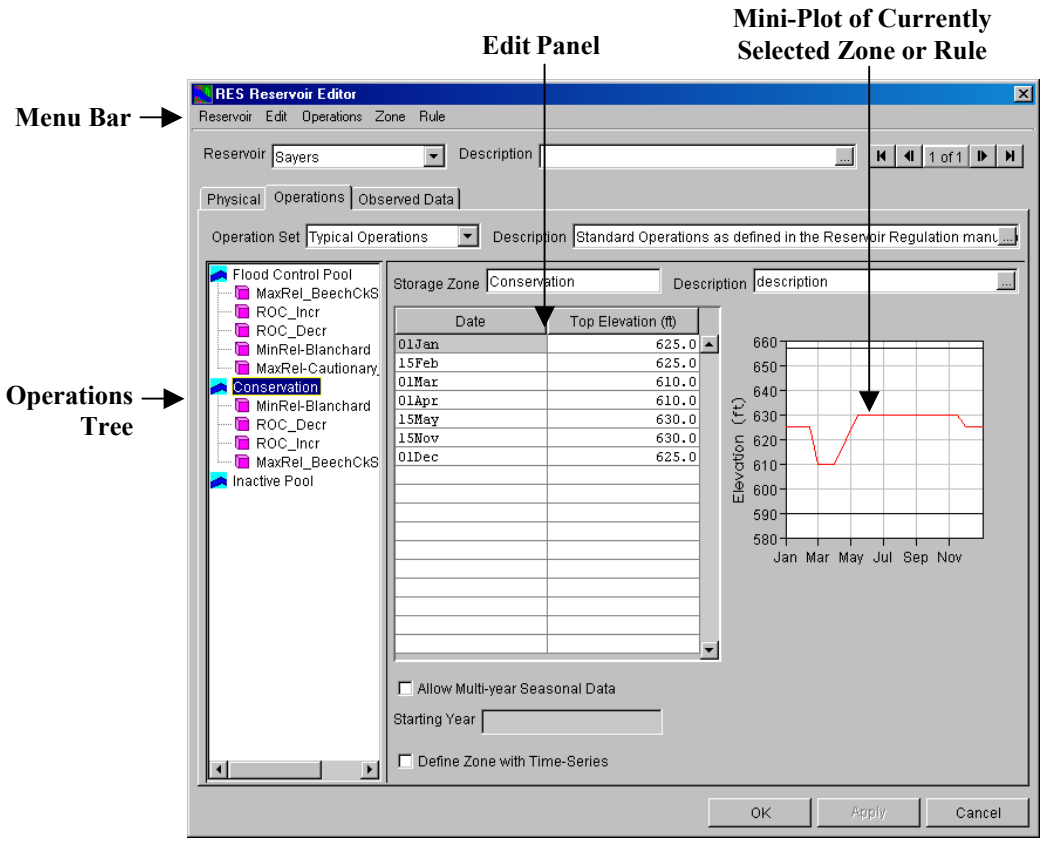

Figure 11.1 Reservoir Editor--Operations Tab

When the Operations tab is selected for display in the Reservoir Editor, the **Menu Bar** at the top of the editor changes to include three menus unique to the Operations tab. They are **Operations**, **Zone**, and **Rule**. These menus provide the options for creating and deleting operation sets, zones, and rules, respectively. These options, as well as others, will be covered in detail later in this chapter.

The **Operations Tree** displays the zones you have defined for the current operation set. With each new operation set, ResSim creates a default set of zones that includes **Flood Control**, **Conservation**, and **Inactive**. Beneath each zone in the tree is a prioritized list of the rules that apply to that zone. As you add zones and rules to the reservoir, the tree will expand to show them.

The **Edit Panel** changes depending upon the element you have selected in the operations tree. If you select a zone, the zone editor will appear. If you select a rule, the specialized rule editor for that rule type will be displayed. A **mini-plot** on the right side of the Edit Panel reflects the data you enter in the table of the current editor. The mini-plot can be viewed in full size when you double-click on it.

At the top of the Reservoir Editor, the **Reservoir** field contains a list of all of the reservoirs in your network, with the name of the current reservoir displayed. You can access all of the reservoirs in your network either from this list or by using the VCR-style buttons to navigate through the available reservoirs. Beside the Reservoir name list is the **Description** of the current reservoir; this field is editable. Use the description field to keep notes on decisions you made while developing the data for the reservoir, your plans, intentions, references, etc. You can enter a longer description by using the  button to access the full text editor for the description.

11.2 Reservoir Operation Sets

An **Operation Set** is the operation plan or scheme upon which a reservoir bases its decisions regarding how much water to release at each time step of a simulation run. You can define multiple operation sets for each reservoir, but an individual alternative can follow only one operation set per reservoir.

This section describes how to create and edit an operation set. The next section (Section 11.3) describes how to configure the zones within your operation set.

11.2.1 Creating a New Operation Set

To create a new Operation Set:

1. Select **New** from the **Operations** menu of the Reservoir Editor. The **New Operation Set** dialog box will open (Figure 11.2).
2. Give the new operation set a **Name** and a **Description**.

3. Click **OK** to complete the process and to close the dialog box.

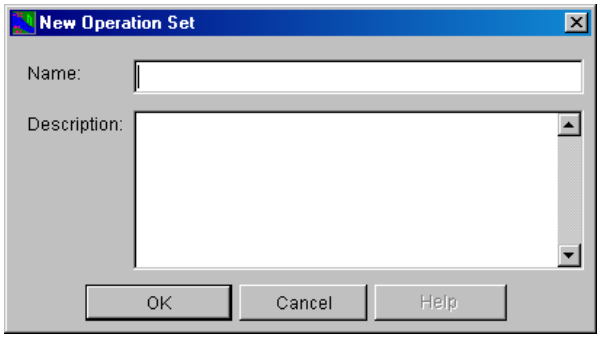

Figure 11.2 New Operation Set Dialog Box

The name you entered will now appear in the **Operation Set** list, and the description will appear in the **Description** field. The Description field is editable. Use the description to describe the purpose of the operation set, the expected behavior the operation set should provide, and any changes you had to make to accomplish your goal.

ResSim establishes a default set of zones within the new operation set. These zones are **Flood Control**, **Conservation**, and **Inactive**. These zones can be renamed or removed. However, the **Inactive** zone is a special zone in the operation set. It represents the "dead" storage of the reservoir. The reservoir cannot release water from the Inactive pool and rules cannot be added to this zone. *If you remove the **Inactive** zone from the operation set, it cannot be reestablished.*

11.2.2 Renaming an Operation Set

To rename an operation set:

1. Select **Rename** from the **Operations** menu of the Reservoir Editor. The **Rename Operation Set** dialog box will open (Figure 11.3).
2. Give the operation set a new **Name**.
3. Click **OK** to complete the rename process and to close the dialog box. A confirmation dialog box will appear asking if you really want to rename the selected operation set.

Figure 11.3 Rename Operation Set Dialog Box

11.2.3 Copying an Operation Set

To copy (or duplicate) an operation set:

1. Select the Operation set you want to make a copy from the **Operation Set** list on the Operations tab.
2. Select **Duplicate** from the **Operations** menu of the Reservoir Editor. The **Duplicate Operation Set** dialog box will open (Figure 11.4).
3. Give the operation set a new **Name** and a **Description**.
4. Click **OK** to complete the copy process and to close the dialog box.

The new operation set will have a copy of all the zones that were in the original operation set. Each zone in the new operation set will also list the same rules that were used by the original operation set.

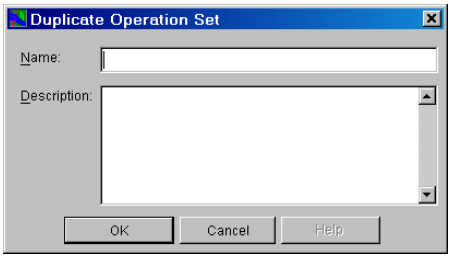

Figure 11.4 Duplicate Operation Set

11.2.4 Deleting an Operation Set

To delete an operation set:

1. Select **Delete** from the **Operations** menu of the Reservoir Editor. The **Select Operation Set to Delete** dialog box will open (Figure 11.5).
2. Highlight the operation set you wish to delete. Its name should appear in the grey box at the bottom.
3. Click **OK** to complete the delete process and to close the dialog box. A confirmation dialog box will appear asking if you really want to delete the selected operation set.

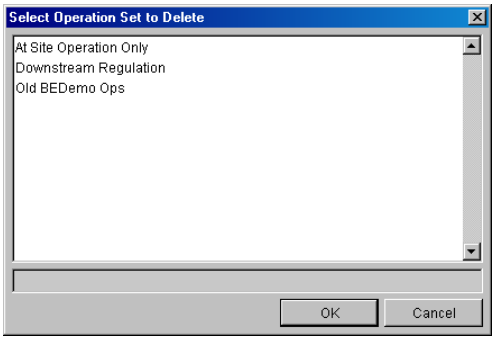

Figure 11.5 Select Operation Set to Delete

11.2.5 Editing an Operation Set

At the top of the Operations tab, the **Operation Set** field contains a list of all of the operation sets for your reservoir, with the name of the current operation set displayed. Use this list to select the operation set you wish to edit. The Operations tab will fill with the data for the selected operation set.

Beside the **Operation Set** name list is the **Description** of the current operation set; this field is editable. Use the description to describe the purpose of the operation set, the expected behavior the operation set should provide, and any changes you had to make to accomplish your goal. You can enter a much longer description by using the ... button to access the full text editor for the description.

The remainder of this chapter will detail all the options available for editing your operation set. Each section assumes that you have already created an operation set. If you have not, go back and do so (see Section 11.2.1).

11.3 Reservoir Operation Zones

As illustrated in Figure 11.6, when you create a new Operation Set, ResSim automatically creates three default reservoir operation zones: **Flood Control**, **Conservation**, and **Inactive**. You may wish to rename these default zones and add descriptions. You may need to define additional zones as well. This section will detail how to edit the zone definitions of your operation set.

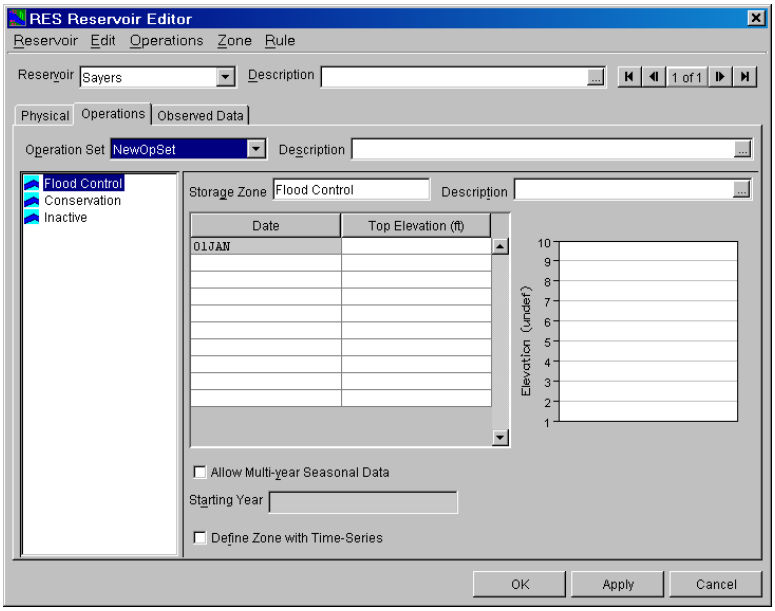

Figure 11.6 Reservoir Editor Showing New Operation Set

11.3.1 Renaming and Describing Operation Zones

To change the name of a Zone as it appears in the operations tree and/or edit its description:

1. Select the Zone in the operations tree.
2. Enter the new name and/or description in the editable **Storage Zone** name field and/or **Description** field of the editor.

Any changes you make to the **Storage Zone** name field will be reflected in the operations tree.

*Renaming the **Inactive** zone does not change its nature. The inactive zone is still a special zone from which the reservoir cannot release water and no rules can be applied to this zone.*

11.3.2 Adding a New Reservoir Storage Zone

To add a new Reservoir Storage Zone:

1. Select **New** from the **Zone** menu of the Reservoir Editor. The **New Zone** dialog box will open (Figure 11.7).
2. Enter a **Name** and **Description** for the new zone.
3. Click **OK** to complete the new process and close the **New Zone** dialog box.

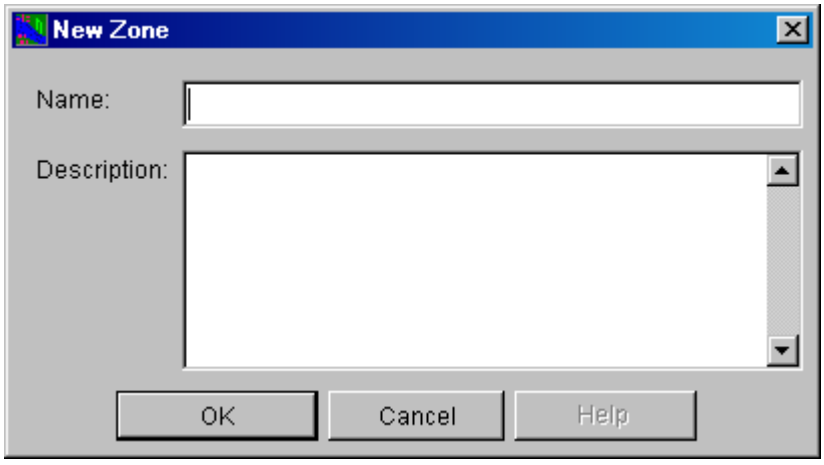

Figure 11.7 New Zone Dialog Box

The new zone you created now appears in the operations tree. Complete the creation of the zone by defining the curve that represents the top of the zone, as explained in the next section.

11.3.3 Defining Operation Zones

You will need to define the curves representing the top of each zone you have created. A table of dates and elevations defines each curve. The first date in the table is always 01Jan. The curve is defined by straight lines connecting the points defined in the table. By default, the table represents one year, so the last point connects back to the first as the year repeats. If your curve represents more than one year, follow the instructions in Step 3 below for creating a multi-year curve, or follow the instructions in Step 4 below for reading the top of zone from HEC-DSS.

When the selected feature in the operations tree is a Zone, the **Zone Editor** is displayed in the Edit Panel and the mini-plot at the right will illustrate the curves representing the top of each zone. The color of the selected zone's curve will be red. All other zones will be black.

Figure 11.8 shows the curve definition for a zone named **Conservation.**

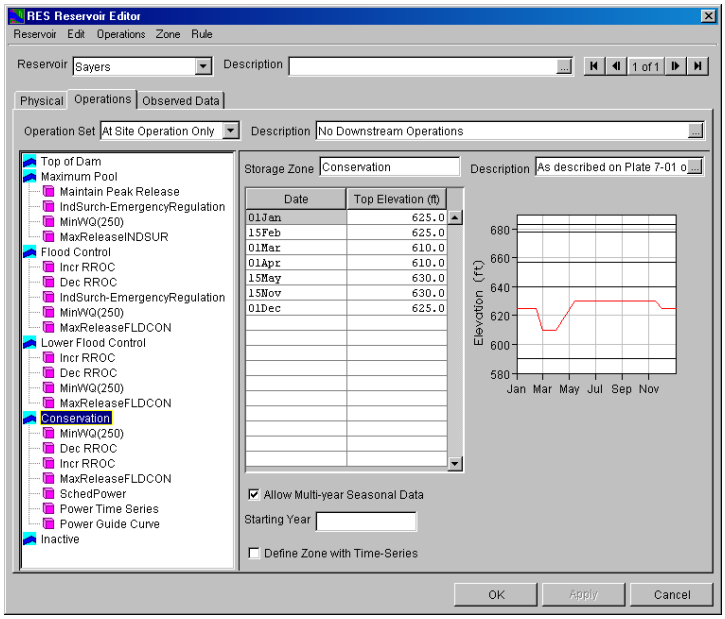

Figure 11.8 Reservoir Editor--Operations Tab: Zone Editor

To define the top of zone curves, do the following for each zone:

1. Select the Zone in the operations tree to access the **Zone Editor** containing the data for that zone.
2. Enter the **Date** and **Top Elevation** values in the table to define the curve for the zone. You can either copy and paste data from a spreadsheet application or type in the values manually. Note that dates often do not copy and paste correctly and must be entered manually.

Be careful when copying "Date" data from a spreadsheet. Most spreadsheet applications use their own specialized numeric format for dates. Only 'text' can be pasted into a date cell in ResSim.

Dates are entered in a ddmmm format with the month as a three-letter abbreviation. Dates can also be entered with the calendar tool (which can be accessed by double-clicking in a date cell and then clicking the small ellipse button that appears on the right side of the cell).

3. If you wish to **Allow Multi-year Seasonal Data** for the top of zone definition, select this checkbox and enter a four-digit year as a reference for the start of the table. The multi-year table will repeat if the simulation time window overlaps the span of the table. Type in the starting year of the table in the Starting Year field.
4. If you wish to define the zone with a HEC-DSS time-series record, select the **Define Zone with Time Series** check box. You will still need to define a default zone in the table, but that zone definition will be overridden by the time series that you will later select for the zone on the time-series tab of the Alternative Editor (see Chapter 13, Section 13.7).
5. When you have finished entering top of zone curves for a zone, be sure to click the **Apply** button before moving on to the next zone. Be careful when defining each zone curve – zones should NOT cross each other.

11.3.4 Deleting Operation Zones

To delete a zone from an operation set:

1. Select the Zone you wish to delete from the operations tree.
2. Select **Delete** from the **Zone** menu or select **Delete** from the shortcut menu by right-clicking on the zone you wish to delete in the operations tree.
3. Click **OK** in the **Delete Storage Zone** dialog box to complete the delete process.

The Inactive Zone is a special zone in the operation set. If you delete the Inactive Zone from the operation set, it cannot be reestablished.

11.4 Understanding Reservoir Operation Rules

Operation Rules represent the flow goals and constraints upon the releases for each zone of the operation set. Each zone can contain a different set of rules depending on the flow limits and requirements of that zone within the regulation plan. As previously described in Section 11.3.3 and illustrated in Figure 11.8, the rules and zones appear in the **Operations Tree** on the left side of the Reservoir Editor's Operations tab window.

11.4.1 Release Decision Process

When a set of rules exist within a reservoir zone, the decision logic first determines what the release would be for *Guide Curve* operation (see Section 11.8). Then, working from the "lowest to the highest" priority rule, the program adjusts the release to meet each rule. If two rules contradict each other, the higher priority rule applies (see Section 11.4.5 for a description of prioritizing rules).

The release decision process has 3 basic steps:

1. Identify the maximum and minimum *physical limits* on the release. This is the allowable release range.
2. Narrow the allowable *release range* by applying the rules in the current zone, starting with the highest priority rule (see Section 11.4.5 for a description of prioritizing rules). For example, if a higher priority rule defines a more restrictive limit on the range that is currently defined by a lower priority rule, then the more restrictive limit is applied. However, if a rule defines a limit outside the current range, then the rule is ignored.
3. Evaluate the desired release for the basic *Guide Curve* operation (see Section 11.8). This is the release needed to get the reservoir to the guide curve in the current time step (computation interval) based on the starting pool elevation, the prior release, and the current inflow.

If the desired release falls within the allowable release range, then the release decision will be the desired release determined in Step 3 above. However, if the desired release is outside the allowable release range determined in the first two steps above, the release will be set to the limit closest to the desired value.

11.4.2 Using Existing Rules

Once you have defined a rule, you can include it in more than one zone by selecting **Use Existing** from the **Rule** menu of the Reservoir Editor.

Rules belong to the Reservoir in the current Network, not to a zone or to an operation set. Therefore, any given rule can be used in more than one zone and in more than one operation set. So, be careful – a change to a reservoir's rule in one operation set carries through all operation sets in the current Network that use that rule.

11.4.3 Removing Rules

You can remove a rule from a zone by highlighting the rule in the operations tree and then selecting **Remove** from the shortcut menu (or select **Remove from Zone** from the **Rule** menu of the Reservoir Editor). Removing a rule from a zone does not delete the rule. The rule still exists in the reservoir for inclusion in other zones and operation sets.

11.4.4 Deleting Rules

To delete a rule from the reservoir, you can use the **Delete** option from the **Rule** menu. ***Use caution when deleting rules.*** When you delete a rule, it will no longer be available in any of the zones in this, or any other, operation set for this reservoir in the current reservoir network.

11.4.5 Prioritizing Rules

You must prioritize the rules within a zone, with the highest priority rule being at the top of the list. To raise or lower the priority of a rule within the rule list for the current zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu. In Section 11.5, pay special attention to the discussion for each rule type. Some rules, such as the Induced Surcharge rule (see Section 11.5.6), may need to be the highest priority rule in a zone.

11.4.6 Renaming Rules

To rename a rule, highlight the rule in the operations tree and select **Rename** from the shortcut menu (or select **Rename** from the **Rule** menu of the Reservoir Editor). ***Use caution when renaming rules.*** If you rename a rule, all instances of the rule will be renamed (i.e., the rule's existence within all reservoir zones and operations sets for the reservoir in the current reservoir network).

11.5 Defining Reservoir Operation Rules

This section explains how to define a variety of rules using the different rule types available in ResSim for reservoir Pools, Outlets, and Outlet Groups. Rule types differ depending on whether you apply the rule to the reservoir **Pool**, to a **Dam** (or an **Outlet Group** or **Diverted Outlet**), or to a **Controlled Outlet**. The Operations tab of the Reservoir Editor provides a separate editor for each rule type, as listed below and described in subsequent sub-sections.

Rules for the **Reservoir Pool** include:

- Release Function
- Downstream Control Function
- Tandem Operation
- Induced Surcharge
- Flow Rate of Change Limit
- Elevation Rate of Change Limit

Rules for the **Dam** and **Outlet Groups** and **Diverted Outlets** are as follows:

- Release Function
- Flow Rate of Change Limit

Rules for the **Controlled Outlets** are as follows:

- Release Function
- Flow Rate of Change Limit
- Hydropower Requirements:
    - Hydropower Schedule – Regular
    - Hydropower Schedule – Time Series
    - Power Guide Curve

11.5.1 Adding a New Operation Rule to a Zone

When you create a rule, you must name it, assign the rule to a specific sub-element of the reservoir, and select the rule type. The list of available sub-elements includes: the reservoir **Pool** (identified by the name of the reservoir); the **Dam** (identified by the reservoir name hyphenated with the dam name), **Outlet Groups**, and **Diverted Outlets**; and, all user-defined **Controlled Outlets**.

To add a new operation rule to a zone:

1. Highlight the appropriate Zone in the operations tree.
2. Select **New** from the **Rule** menu of the Reservoir Editor. The **New Operating Rule** dialog box will open.
3. Select the control element of the reservoir to which you will assign this rule (reservoir pool, dam, outlet group, outlet) from the **Operates Release from** list (Figure 11.9).

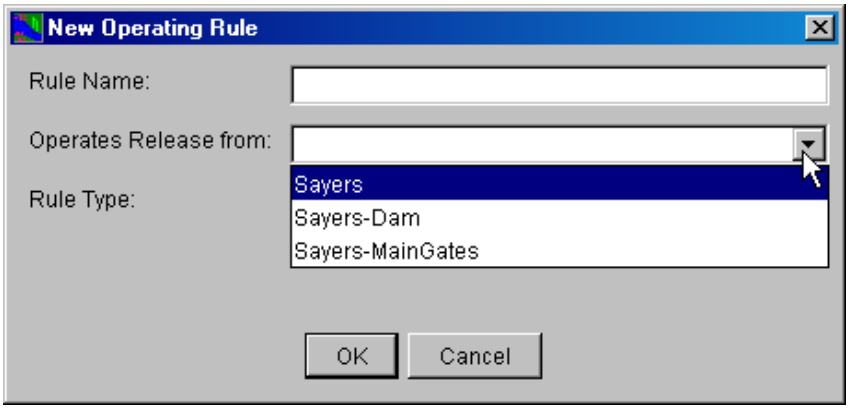

Figure 11.9 New Operating Rule Dialog Box

4. Select the **Rule Type** from the list. The available rule types will depend upon whether you have selected a pool, dam, outlet, or outlet group, as listed in Section 11.5
5. Enter a **Name** for the new rule.
6. Click **OK** to close the **New Operating Rule** dialog box.

The new rule will appear, highlighted, in the operations tree and the edit panel will display the rule editor based on the rule type. The first two fields for each rule editor contain the name of the rule and its description. These fields are editable, however, use care when editing a rule name – all instances of the rule (in all operation sets) will be updated. See the appropriate section below to determine how to define the data for your new rule.

11.5.2 Adding an Existing Rule to a Zone

Once you have created a rule in a zone, you may want to use that same rule in another zone so you do not have to create a new rule in the other zone.

To add an existing operation rule to a zone:

1. Highlight the appropriate Zone in the operations tree.
2. Select **Use Existing** from the **Rule** menu of the Reservoir Editor or **Use Existing Rule** from the zone's shortcut menu. The **Select Existing Rule** dialog box will open (similar to Figure 11.10 which shows an example list of existing rules).

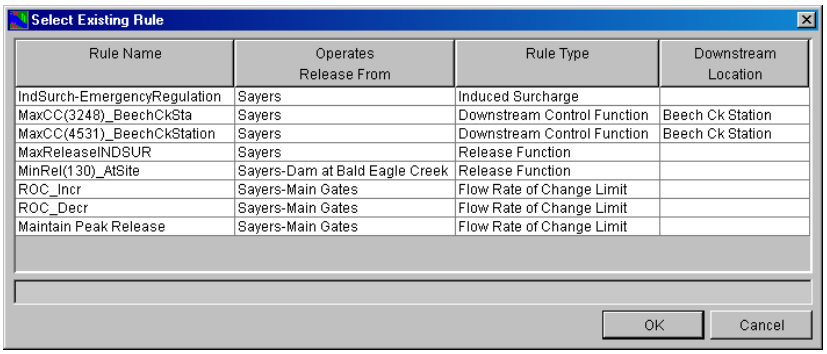

Figure 11.10 Select Existing Rule Dialog Box

3. Select the rule you want to add from the list. Only those rules defined for the current reservoir *but not yet used in the current zone* will be listed.
4. Click **OK** to complete the Use Existing process and close the dialog box.

11.5.3 Defining a Release Function Rule

The **Release Function** rule type is one of the two most powerful rule types available (the other being the **Downstream Control Function** rule). With this rule type, you can define a wide array of rules, any of which can be described as a "function of" rule. This rule can be assigned to any of the release elements (pool, dam, or outlet) and it allows you to specify the maximum, minimum, or *specified* flow to be released through the release element.

Use **specified** *with caution. Most operation rules describe either a minimum or maximum limit. Specified rules describe the precise amount of flow to be released, neither more or less, making them effectively both a minimum and a maximum limit at the same time. A specified release rule, therefore, sets the allowable range of the release to a single value.*

The simplest rules to define with this rule type are those where the release limit is a "function of date". Rules of this type are seasonally-varying release limits. For example: "the maximum release from the reservoir during the growing season is 6500 cfs and 8500 cfs during the non-growing season".

The more complex rules that you can create with the Release Function rule type are those where the release limit is a function of an internal (model) variable or an external variable, such as a rule where the minimum release is a function of the inflow to the reservoir. Inflow to the reservoir is just one of many internal or "model" variables that can be used to create a "function of model variable" rule. The "function of external variable" rule is also very powerful, limited only by your imagination and the time-series data available. An example of an "external variable" rule might be one where the minimum release is a function of dissolved oxygen at a specific gage. Since ResSim cannot compute dissolved oxygen, a time-series record that describes the predicted or observed values for that variable would be used to influence the release based on the function you define.

To define a Release Function rule:

1. To create a new Release Function rule, follow the instructions in Section 11.5.1. Be sure to select **Release Function** for the **Rule Type** in the **New Operating Rule** editor.
2. Highlight the appropriate rule in the operations tree to access the **Release Function** rule editor (Figure 11.11). The name and description of the rule will appear in the **Rule Name** and **Description** fields.

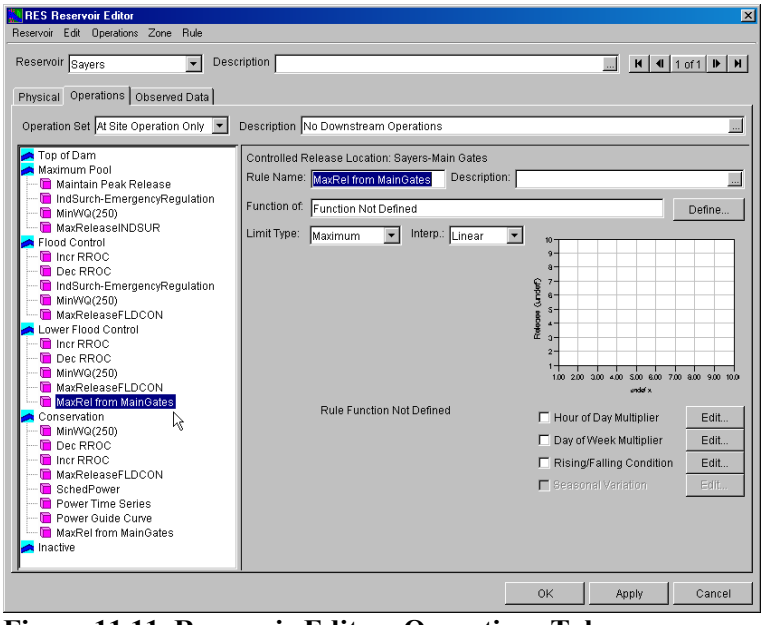

Figure 11.11 Reservoir Editor--Operations Tab: New Release Function Rule

3. Define the Release Function:
   - Click the "Function of:" **Define** button. The **Independent Variable Definition** editor will open (Figure 11.12).

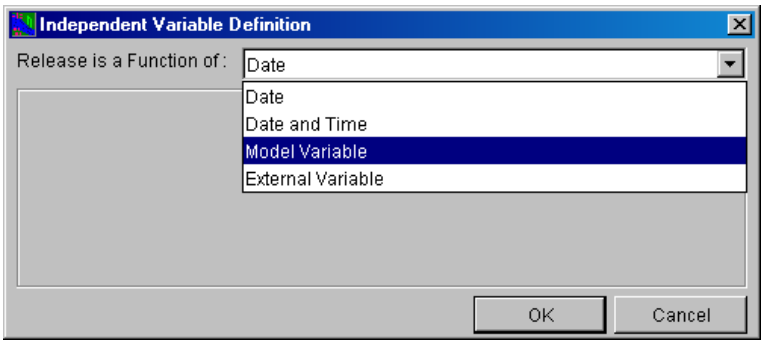

Figure 11.12 Reservoir Editor--Operations Tab: Release Function Rule, Selecting a Function from the Independent Variable Definition Editor

   - Select the function type from the "**Release is a Function of**" list: **Date**, **Date and Time**, **Model Variable** or **External Variable**.
   - If the function type is **Model Variable**, select the independent variable using the **Filter** chooser (Figure 11.13).

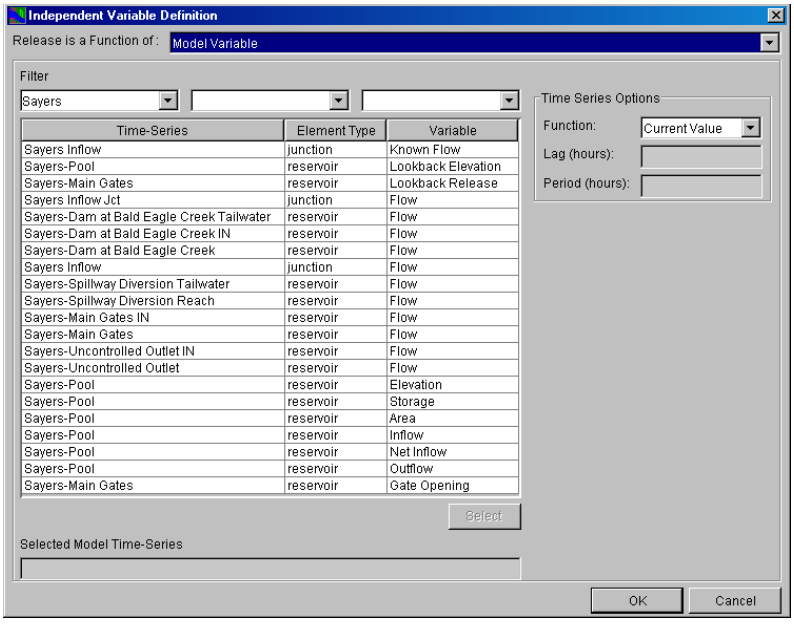

Figure 11.13 Reservoir Editor--Operations Tab: Release Function Rule, Selecting an Independent Variable from the Model Variable List

- If the function type is **External Variable**, identify the independent variable in the name field (Figure 11.14). This name will appear on the time-series tab of the Alternative Editor (see Chapter 13, Section 13.7).

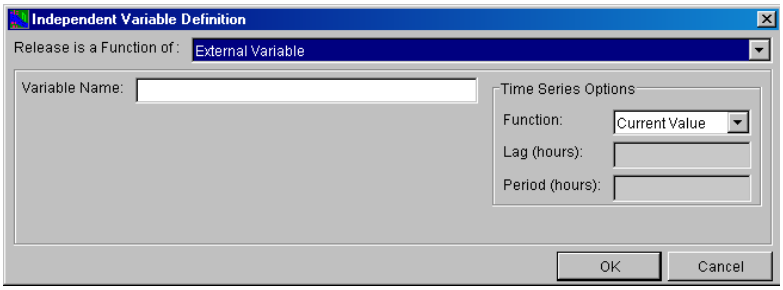

Figure 11.14 Reservoir Editor--Operations Tab: Release Function Rule, Defining an External Variable as the Independent Variable

- If desired, for either the Model or External variables, select the **Time Series Options** for the independent variable. From the **Function** list (Figure 11.15), you can select **Current Value**, **Previous Value**, **Lagged Value**, **Period Average**, **Period Maximum**, and **Period Minimum**. The **Lag** (in hours) can be specified (for all but Current and Previous value) along with the appropriate **Period** (in hours).

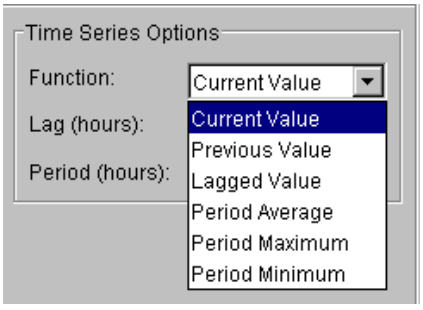

Figure 11.15 Time Series Options for Model and External Variables

- Click **OK** to complete the definition of the independent variable of your function.

4. Set the **Limit Type** as Minimum, Maximum or *Specified*.

Use **specified** *with caution. Most operation rules describe either a minimum or maximum limit. Specified rules describe the precise amount of flow to be released, neither more or less, making them effectively both a minimum and a maximum limit at the same time. A specified release rule, therefore, sets the allowable range of the release to a single value.*

5. Select the **Interpolation Type** as Linear, Cubic, or Step (see Section 11.6.1 for a description of how the interpolation types work).

6. Define the function using the table in the release function rule editor (see Figure 11.16). You can either copy and paste data from a spreadsheet application or type in the values manually.

> *Be careful when copying date data from a spreadsheet. Most spreadsheet applications use their own specialized numeric format for dates. Only 'text' can be pasted into a date cell in ResSim.*

   The mini-plot will reflect the values you enter and can be viewed in full size when you double-click on it.

   - If using a function of date, you can enter a single value for 01 Jan to describe a constant release limit throughout the year or enter multiple dates to define a seasonally varying release limit rule. Dates can also be entered with the calendar tool, which can be accessed by double-clicking in a date cell then clicking the ellipse button that appears.
   - If your rule is a function of variable rule, you can make your rule *seasonally varying* by using the **Seasonal Variation** option. Refer to Section 11.6.5 for more details.

7. If you wish to use **Hour of Day** or **Day of the Week Multipliers**, refer to Sections 11.6.2 and 11.6.3 for more details.
8. To make your rule applicable only under rising (or falling) conditions, use the **Rising/Falling Condition** option. Refer to Section 11.6.4 for details.
9. Check the position of your new rule with respect to the other rules in this zone. To raise or lower the priority of a rule within the rule list for the current zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.

An example of a completed **Release Function** rule is shown in Figure 11.16. When you have finished entering data for the Release Function rule, be sure to click the **Apply** button before moving on to the next rule.

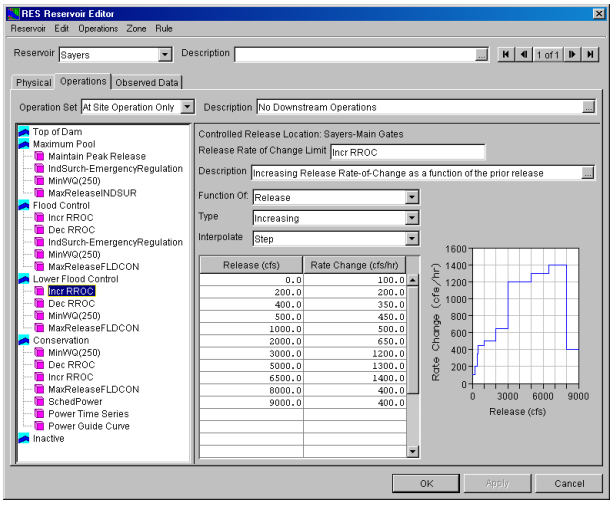

Figure 11.16 Reservoir Editor--Operations Tab: Example of Completed Release Function Rule

11.5.4 Defining a Downstream Control Function Rule

This rule type (and its editor) is an extension of the Release Function rule described in Section 11.5.3. Downstream control rules describe the minimum or maximum flow (e.g., flow requirement or channel capacity) or stage at a control point rather than an explicit limit on the release. The final release limit will be determined based on the influence of routing and cumulative local flows at the downstream control point.

In addition, the Downstream Control rules can be used to create system operation (where two or more parallel reservoirs are operated to have balanced storages while controlling for common downstream requirements). Once created for one reservoir, the Downstream Control rule will also be available in the List of Existing Rules (refer to Section 11.5.2) for other reservoirs in the network. *To establish a system operation, the same downstream control rule must be used in each applicable reservoir's operation set.* Chapter 12 discusses ResSim's methodology for system operation and storage balancing.

When creating the Downstream Control rule, it can be assigned only to the *reservoir* (pool), not to a specific outlet or outlet group, because only the reservoir can account for all releases from the reservoir's outlets that could influence the flow at the downstream control point.

To enter operations data for a Downstream Control Function rule:

1. To create a downstream control rule, follow the instructions for creating a new rule as described in Section 11.5.1. After selecting the **Operate Release from** to be the *reservoir* and the **Rule Type** to be **Downstream Control Function**, be sure to select the downstream control point from the **Downstream Location** list that appears when you select the Downstream Control Function rule type. Figure 11.17 illustrates the creation of a Downstream Control Function rule.

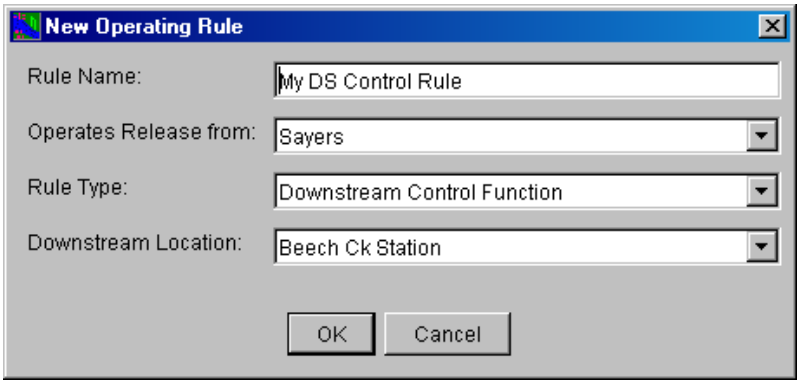

Figure 11.17 Reservoir Editor--New Operating Rule: Downstream Control Function

2. To define your downstream control rule, refer to Section 11.5.3 detailing how to define a Release Function rule. The Downstream Control Function rule editor is essentially the same as the Release Function rule editor. The only significant difference is that you have the option of defining the rule as a minimum or maximum **Flow** or **Stage** parameter limit at the downstream control point (see example in Figure 11.18).

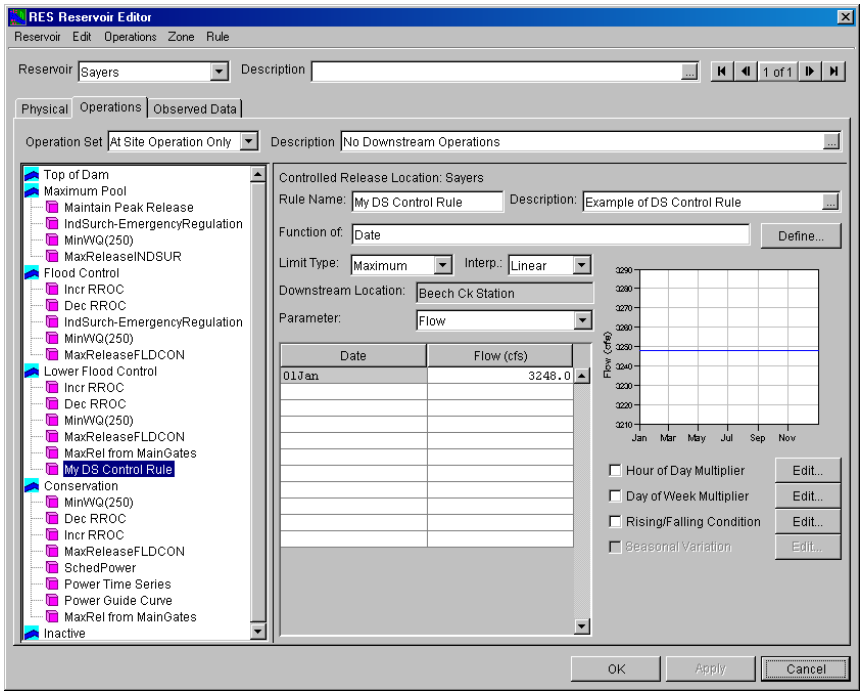

Figure 11.18 Reservoir Editor--Example of a Downstream Control Function Rule

3. Check the position of your new rule with respect to other rules in the zone it is placed. To raise or lower the priority of a rule within the rule list for a particular zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.
4. When you have finished entering data for the Downstream Control Function rule, be sure to click the **Apply** button before moving on to the next rule.

After a downstream control rule has been defined, the downstream location in the display area will have a box drawn around the junction symbol.

11.5.5 Defining a Tandem Operation Rule

A **Tandem Operation** rule establishes a tandem system operation where an upstream reservoir operates for a downstream reservoir to achieve a storage balance. Unlike the Downstream Control rule, which is the only other rule type used for system operation and must be included in the operation sets of all reservoirs in the system, the Tandem Operation rule is created and included in the operation set at the upstream reservoir only. The Tandem Operation rule simply identifies the downstream reservoir that is being operated for. An implicit (default) storage balance scheme is invoked by the Tandem Operation rule, and an optional explicit (user-defined) storage balance scheme can be defined and used instead of the default (refer to Chapter 12 for more discussion on system operation).

When creating the Tandem Operation rule, it can be assigned only to the reservoir (pool), not to a specific outlet or outlet group, because only the reservoir can account for all releases from the reservoir's outlets that could influence the flow into the downstream reservoir.

To enter operations data for a Tandem Operation rule:

1. To create a Tandem Operation rule, follow the instructions for creating a new rule as described in Section 11.5.1. Be sure to select the *reservoir* for the release component (**Operates Release from**) and **Tandem Operation** for the **Rule Type** in the **New Operating Rule** editor. Figure 11.19 illustrates the creation of a Tandem Operation rule.

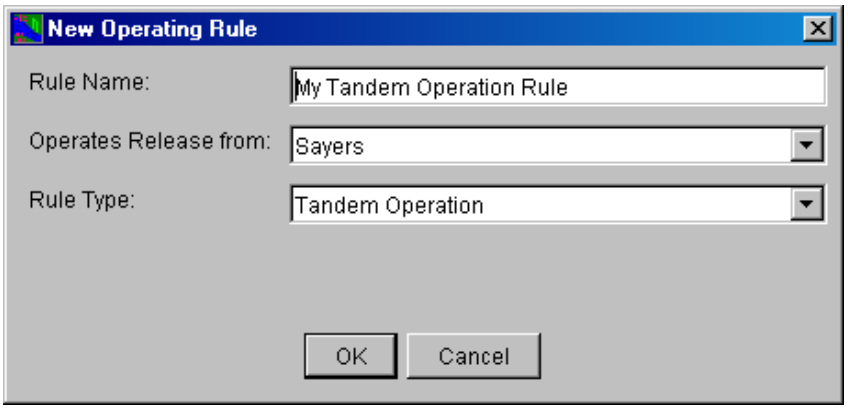

Figure 11.19 Reservoir Editor--New Operating Rule: Tandem Operation

2. To define your Tandem Operation rule, highlight the rule in the operations tree of the reservoir editor (Figure 11.20). In the Edit Panel, you can change the name of the rule, enter a description, and most importantly select the downstream reservoir for which the current (upstream) reservoir is operating.

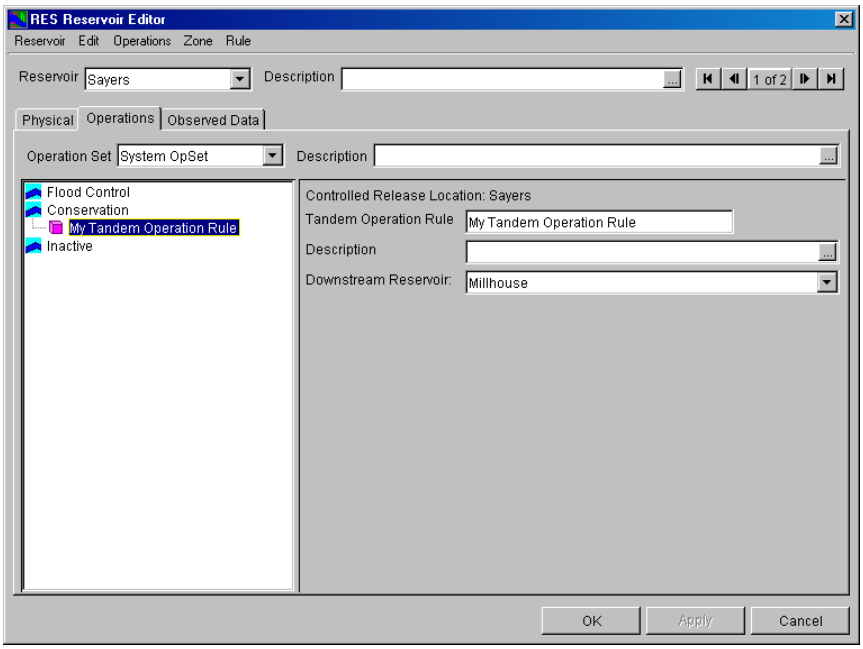

Figure 11.20 Reservoir Editor--Example of a Tandem Operation Rule

3. Check the position of your new rule with respect to other rules in the zone it is placed. To raise or lower the priority of a rule within the rule list for a particular zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.
4. When you have finished setting up the Tandem Operation rule, be sure to click the **Apply** button before moving on to the next rule.

11.5.6 Defining an Induced Surcharge Rule

Induced Surcharge is a flood control operation that specifies emergency releases when the current pool elevation and rate of increase in inflow (or change in pool elevation) threaten to overtop the dam. This operation may necessitate releases that exceed channel capacity constraints. A reservoir must have a gated outlet to employ induced surcharge operations.

Induced Surcharge operation is achieved by physically regulating the position of spillway gates. When the gate opening is reduced to limit release to less than free overflow (the fully-open position), water is intentionally surcharged—or stored—behind the gates. For this reason, induced surcharge is also referred to as a gate regulation operation. Induced Surcharge operation allows operators to better manage a flood event by using additional reservoir storage volume above the spillway crest.

In HEC-ResSim, the Induced Surcharge rule must be defined and entered as the *highest priority rule* in every zone spanning elevations between the top of the dam and the lowest elevation from which the gate can be regulated, generally, the controlled spillway crest. Additionally, a Release Function rule (see Section 11.5.3) with **Limit Type** set to **Maximum** must be defined and entered as a lower priority rule in each of the applicable zones (below the induced surcharge rule). This maximum flow corresponds to the maximum discharge when surcharge operations are not in effect. It is essential to enter this maximum flow limit to guide releases back towards flood control operations after surcharge operations finish. Note that when creating a new rule, the Induced Surcharge option is only available if the "reservoir itself" is selected for **Operates Release from:** ("Sayers" in Figure 11.21, not "Sayers-Dam" or "Sayers-Gate").

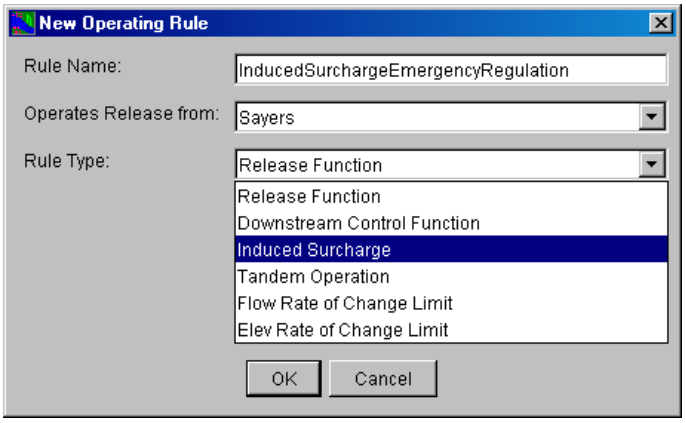

Figure 11.21 Reservoir Editor--Operations Tab: Create Induced Surcharge Rule

Within the **Induced Surcharge** rule editor (Figure 11.22), the **Induced Surcharge Curve**, **Time of Recession**, and **Falling Pool Options** determine the magnitude and duration of gate-regulated releases, and how emergency release should transition back to normal flood control releases. The mini-plot will reflect the **Elevation** vs. **Release** values you enter for the Induced Surcharge Envelope and can be viewed in full size when you double-click on it.

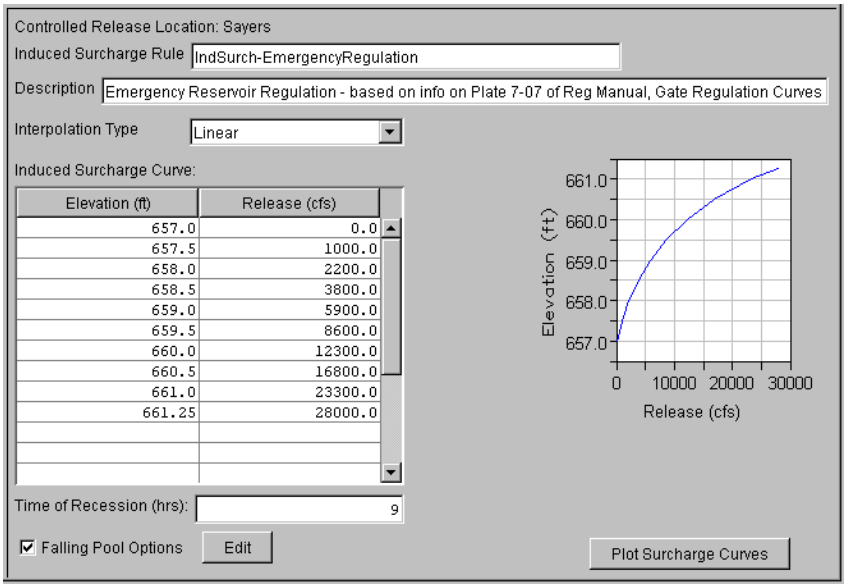

Figure 11.22 Reservoir Editor--Operations Tab: Induced Surcharge Rule

To enter operational data for an Induced Surcharge rule:

1. Highlight the appropriate rule in the operations tree to access the **Induced Surcharge** rule editor (Figure 11.22). The name and description of the rule will appear in the **Induced Surcharge Rule** and **Description** fields.
2. Select the **Interpolation Type** as Linear or Cubic (see Section 11.6.1).
3. Enter **Elevation** and **Release** data into the table to describe the Induced Surcharge Envelope. This envelope defines the lower limit of allowable regulated release when the pool is at a certain elevation. The rule will compute a higher release as described in EM 1110-2-3600 (USACE, 1987). You can either copy and paste data from a spreadsheet application or type in the values manually.
4. Enter the **Time of Recession** in hours. This constant describes the length of time an incoming flood is expected to take to recede. The program uses this time to compute the volume of water that must be evacuated to prevent overtopping the dam. See discussion in EM 1110-2-3600 (USACE, 1987) for further documentation regarding the Recession Time constant parameter (Ts).

5. Select **Plot Surcharge Curves** to see plots of the computed Induced Surcharge Curves (Figure 11.23) based on the data you have entered.

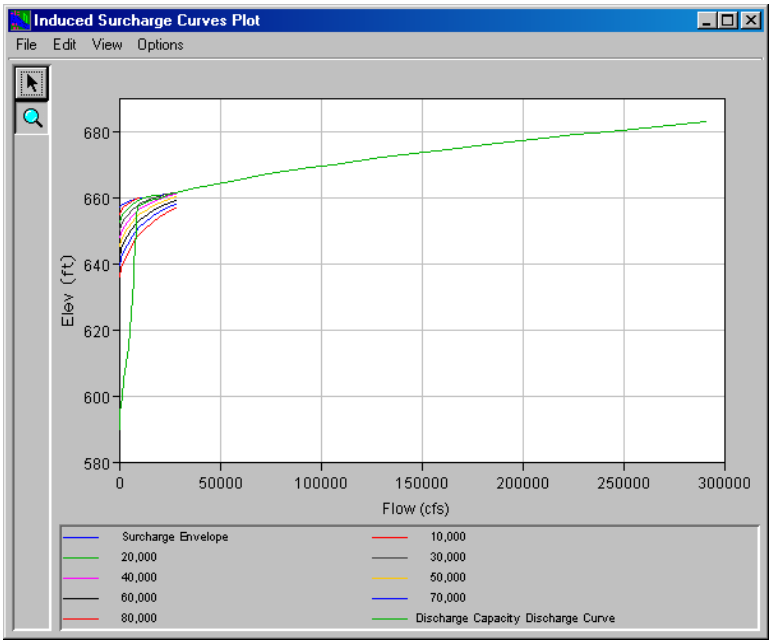

Figure 11.23 Plot of Computed Induced Surcharge Curves

6. Next, select **Falling Pool Options** by clicking the **Edit** button beside the **Falling Pool Options** label. The **Falling Pool Options** dialog box will open (Figure 11.24).

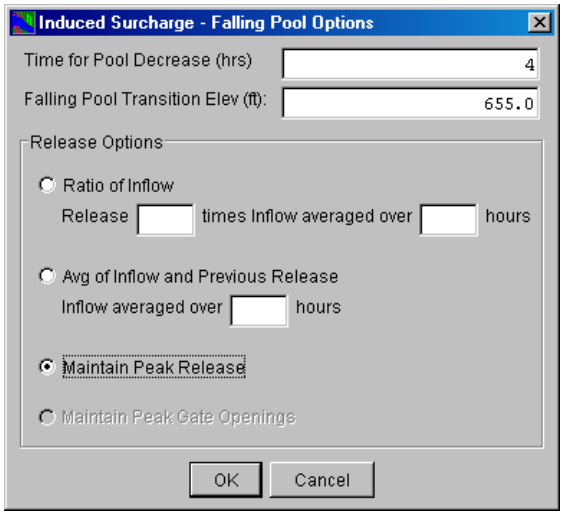

Figure 11.24 Induced Surcharge--Falling Pool Options

7. In the Induced Surcharge - Falling Pool Options dialog box (Figure 11.24), enter the **Time for Pool Decrease** in hours. This parameter describes the required number of successive hours the reservoir pool level must be falling before transitioning from rising pool emergency spillway releases to falling pool releases.

8. Enter the **Falling Pool Transition Elevation** in feet (meters). This parameter represents the pool elevation above which Falling Pool releases will be made. Once the pool elevation falls below this elevation, the Induced Surcharge rule will no longer operate, and ResSim will resume releases based on other rules in the active zone.
9. For **Release Options**, choose Ratio of Inflow, Average of Inflow and Previous Release, or Maintain Peak Release to designate the method for computing falling pool releases. Falling Pool Releases will be made after the pool begins to fall and until the pool level returns to the Falling Pool Transition Elevation.
   - For **Ratio of Inflow**, enter the **Release** ratio **times inflow averaged over** number of **hours**.
   - For **Average of Inflow and Previous Release**, enter the number of **hours** for the **Inflow** to be **averaged over**.
10. Click **OK** to close the Falling Pool Options dialog and a checkmark will display in the box beside **Falling Pool Options** in the Reservoir Editor.
11. Check the position of your new rule with respect to the other rules in this zone. To raise or lower the priority of a rule within the rule list for the current zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.
12. When you have finished entering data for the Induced Surcharge rule, be sure to click the **Apply** button before moving on to the next rule.

11.5.7 Defining a Flow Rate of Change Limit Rule

A **Flow Rate of Change Limit** rule specifies the allowable change when increasing or decreasing release values (i.e., "ramping rates"). A single rule of this type will only limit a rising release or a falling release, but not both. To describe both increasing and decreasing limits, you must define two rules and set the type of one to increasing and the other to decreasing. A rule of this type can be assigned to any release element to influence the behavior of that element.

To enter operations data for a Flow Rate of Change Limit rule:

1. To create a new rule, follow the instructions in Section 11.5.1. Be sure to select **Flow Rate of Change Limit** for the **Rule Type** in the **New Operating Rule** editor.
2. Highlight the appropriate rule in the operations tree to access the **Flow Rate of Change Limit** rule editor (Figure 11.25). The name and description of the rule will appear in the **Release Rate of Change Limit** rule and **Description** fields.

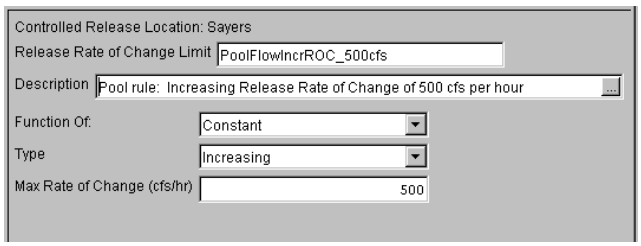

Figure 11.25 Reservoir Editor--Operations Tab: Flow Rate of Change Limit Rule

3. For **Function Of:**, select either **Constant**, **Reservoir Inflow**, **Release**, or **Pool Elevation**.
4. For **Type**, select either **Increasing** or **Decreasing**.
5. Enter the **Max Rate of Change** value. The limit is described in units of flow (cms or cfs) per hour, regardless of the compute interval. For example, if you enter 500 cfs/hr with a compute interval of 12 hours, then this rule describes the maximum flow change per time step as 6000 cfs.
   - If your **Function Of:** selection is **Constant**, enter a single value for the limit.
   - If your **Function Of:** selection is **Reservoir Inflow**, **Release**, or **Pool Elevation**, then a table will appear to allow you to describe how the rate of change is influenced by the selected independent variable. Additionally, select the type of **Interpolation** to apply to the curve as either **Linear**, **Cubic**, or **Step** (see Section 11.6.1).
6. Check the position of your new rule with respect to the other rules in this zone. To raise or lower the priority of a rule within the rule list for the current zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.
7. When you have finished entering data for the Flow Rate of Change rule, be sure to click the **Apply** button before moving on to the next rule.

11.5.8 Defining an Elevation Rate of Change Limit Rule

An **Elevation Rate of Change Limit** rule describes the allowable change when increasing or decreasing pool elevation values. A single rule of this type will only limit a rising pool or a falling pool, but not both. To describe both increasing and decreasing limits, you must define two rules and set the type of one to increasing and the other to decreasing. Since this rule watches the pool elevation, you can assign

this rule only to the pool (reservoir), not to the dam or to a discrete outlet.

To enter operations data for an Elevation Rate of Change Limit rule:

1. To create a new rule, follow the instructions in Section 11.5.1. Be sure to select the *reservoir* for the Release Element and **Elev Rate of Change Limit** for the **Rule Type** in the **New Operating Rule** editor.
2. Highlight the appropriate rule in the operations tree to access the **Elevation Rate of Change Limit** rule editor (Figure 11.26). The name and description of the rule will appear in the **Elevation Rate of Change Limit** Rule and **Description** fields.

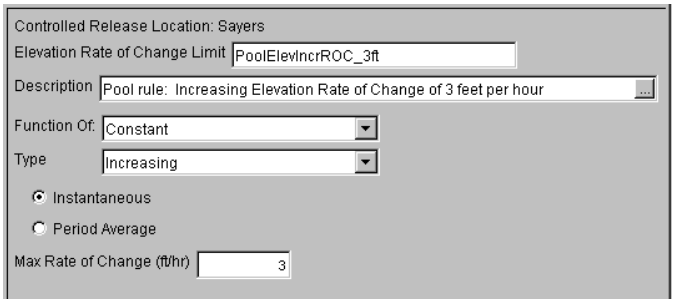

Figure 11.26 Reservoir Editor--Operations Tab: Elevation Rate of Change Limit Rule (Pool)

3. For **Function Of:**, select either **Constant**, **Reservoir Inflow**, or **Release**.
4. For **Type**, select either **Increasing** or **Decreasing**.
5. Choose either **Instantaneous** or **Period Average**.
   - For **Instantaneous**, enter the **Max Rate of Change** value in units of meters (feet) per hour.
   - For **Period Average**, specify the **Max Change** and the number of **Hours** over which the change is allowed.
6. Check the position of your new rule with respect to the other rules in this zone. To raise or lower the priority of a rule within the rule list for the current zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.
7. When you have finished entering data for the Elevation Rate of Change Limit rule, be sure to click the **Apply** button before moving on to the next rule.

11.5.9 Defining Hydropower Rules

There are three different Hydropower rule types (see Figure 11.27) available for you to create a rule that describes a hydropower requirement: **Hydropower – Schedule**, **Hydropower – Time Series Requirement**, and **Hydropower – Power Guide Curve**. Data entry for these rules will be described in the following sub-sections.

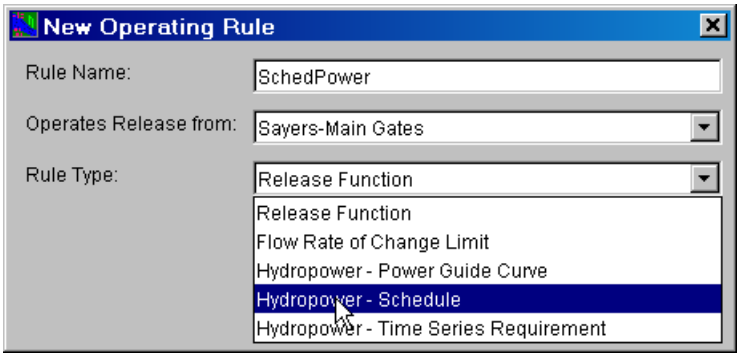

Figure 11.27 Hydropower Rule Types

11.5.9.1 Hydropower – Schedule

The Hydropower – Schedule rule allows you to define a regular *monthly schedule* of hydropower requirements. The various options on this rule editor allow you to define each month's power generation requirement, the form of the specification of the requirement (megawatt-hours or plant factor), and the hours of the day and days of the week during which the plant/outlet can generate.

To define a Hydropower – Schedule Requirement rule:

1. To create a new rule, follow the instructions in Section 11.5.1. Be sure to select the specific outlet containing the power plant for the Release Element and then select **Hydropower – Schedule** for the **Rule Type** in the **New Operating Rule** editor.
2. Highlight the appropriate rule in the operations tree to access the **Hydropower – Schedule** rule editor (Figure 11.28). The name and description of the rule will appear in the **Hydropower – Schedule** rule and **Description** fields.
3. Select the units in which you will specify the requirement (MWH or % Plant Factor).
4. Complete the table by entering the total monthly requirement for each month of the year.

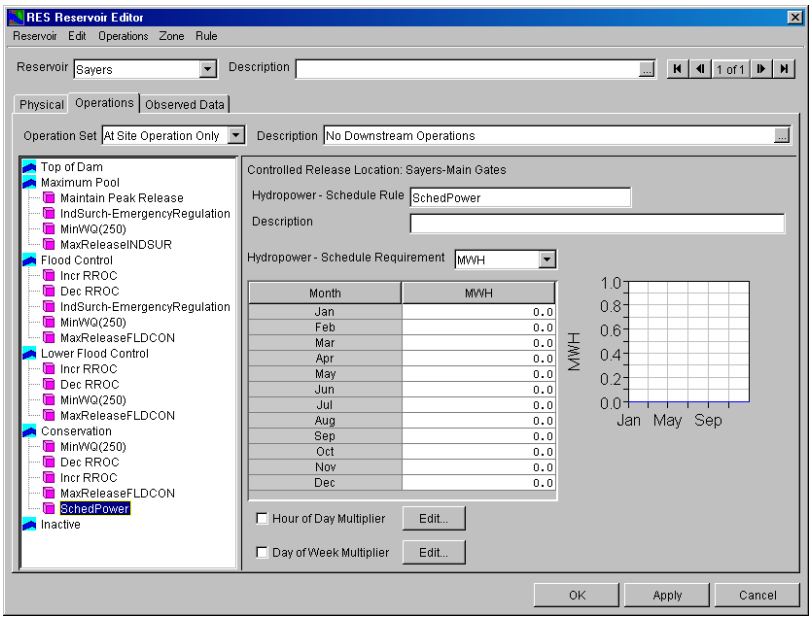

Figure 11.28 Hydropower – Schedule Rule Editor

5. If desired, use **Hour of Day Weighting** and **Day of Week Weighting** factors to define the daily and weekly schedule during which the outlet/plant should operate to meet the monthly requirement. Refer to Sections 11.5.9.4 and 11.5.9.5 for more details.
6. Check the position of your new rule with respect to the other rules in the zone. To raise or lower the priority of your rule within the rule list for the current zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.
7. When you have finished entering data for the Hydropower - Schedule rule, be sure to click the **Apply** button before moving on to the next rule.

11.5.9.2 Hydropower – Time Series Requirement

The Hydropower – Time Series Requirement rule allows you to define an *irregular schedule* of Hydropower requirements through the use of a DSS time-series record. There are no options in this rule editor. Instead, a message is placed there to remind you that you will need to specify a time series of required power in units of megawatts when you develop an alternative that uses this operation set for this reservoir.

To define a Hydropower – Time Series Requirement rule:

1. To create a new rule, follow the instructions in Section 11.5.1. Be sure to select the specific outlet containing the power plant for the Release Element and then select **Hydropower – Time Series**

Requirement for the **Rule Type** in the **New Operating Rule** editor.

2. Highlight the appropriate rule in the operations tree to access the **Hydropower – Time Series Requirement** rule editor (Figure 11.29). The name and description of the rule will appear in the **Hydropower – Time Series Requirement** rule and **Description** fields.

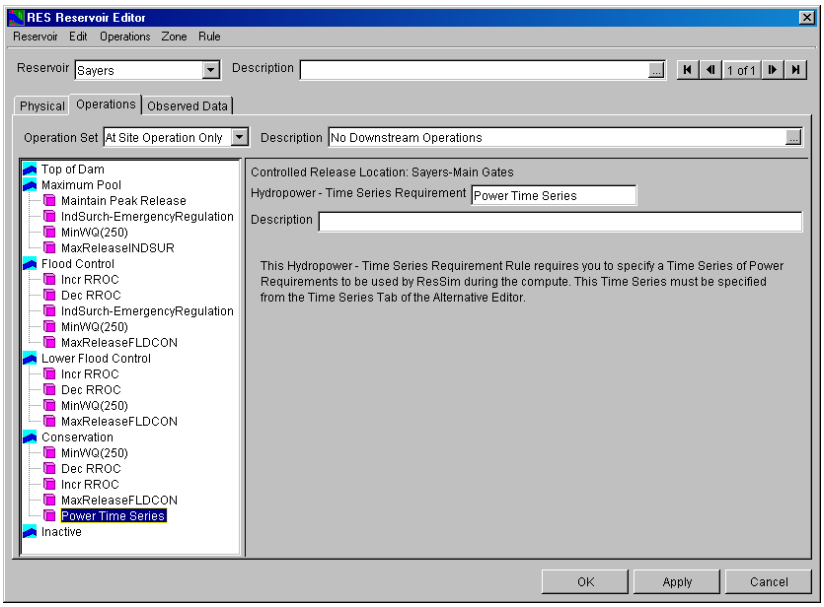

Figure 11.29 Hydropower – Time Series Requirement Rule Editor

3. Make note of the message and the name of the Rule you just created. When you develop an alternative for this network, reservoir, and operation set, you will need to provide a DSS time-series pathname specification for this rule. The entry in the Time Series table of the rule editor will be identified by the rule name with a parameter of power.

11.5.9.3 Hydropower – Power Guide Curve

The Hydropower – Power Guide Curve rule allows you to define a function that describes the hydropower generation requirement with respect to the available storage in the "power pool". The power requirement must be described in units of % plant factor.

To define a Hydropower – Power Guide Curve Requirement rule:

1. To create a new rule, follow the instructions in Section 11.5.1. Be sure to select the specific outlet containing the power plant for the Release Element and then select **Hydropower – Power Guide Curve** for the **Rule Type** in the **New Operating Rule** editor.

2. Highlight the appropriate rule in the operations tree to access the **Hydropower – Power Guide Curve** rule editor (Figure 11.30). The name and description of the rule will appear in the **Hydropower – Power Guide Curve** rule and **Description** fields.

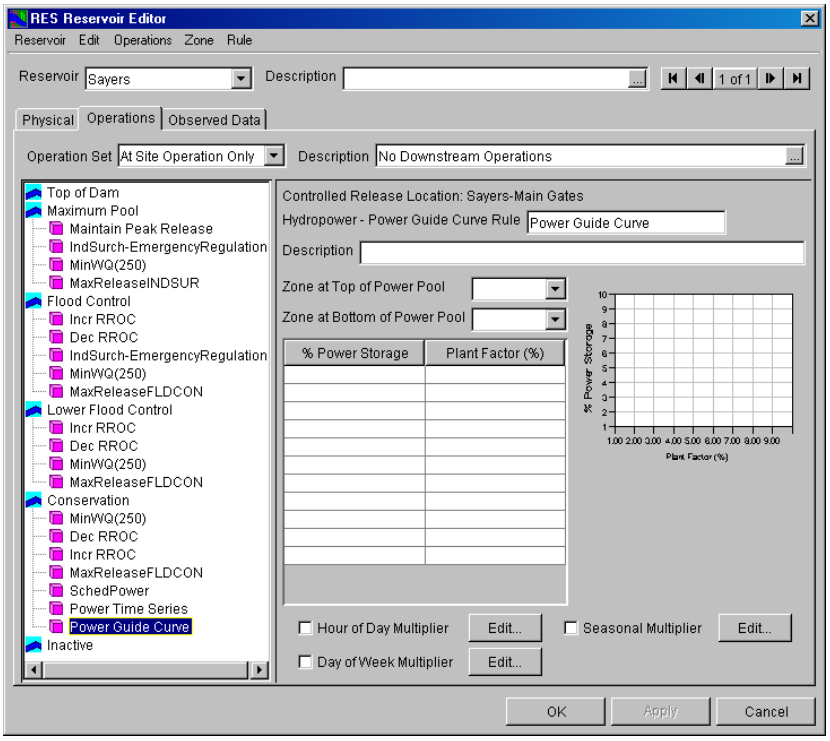

Figure 11.30 Hydropower – Power Guide Curve Rule Editor

3. From the lists for **Zone at Top of Power Pool** and **Zone at Bottom of Power Pool**, select the top of zone curves that bound the top and bottom of the **Power Pool**.
4. Complete the table to define the **Power Guide Curve**. The first column is the *percent of power storage* available in the power pool. These values should increase as you move down in the table. The second column is the *percent plant factor*. This is the power requirement as a percentage of the plant's capacity to generate.
5. If desired, use **Hour of Day Multiplier** and **Day of Week Multiplier** factors to define the daily and weekly schedule during which the outlet/plant should operate to meet the monthly requirement. Refer to Sections 11.6.2 and 11.6.3 for more details.
6. If desired, use **Seasonal Multiplier** factors to raise or lower the requirements throughout the year.
7. Check the position of your new rule with respect to the other rules in the zone. To raise or lower the priority of your rule within the rule list for the current zone, use the **Increase/Decrease Priority** or **Move to Top/Bottom** options in the rule's shortcut menu or from the **Rule** menu.

8. When you have finished entering data for the Hydropower – Power Guide Curve rule, be sure to click the **Apply** button before moving on to the next rule.

11.5.9.4 Hour of Day Weighting Factors

The Hour of Day Weighting Factors allow you to specify an hourly distribution of daily energy requirements (see Section 11.5.9.5) based on the *time of the day*. For example, if you want the power plant to generate during a portion of the day, you can set the factor for those hours to 1.0 and set all other hours to 0.0. To do this, click on the Hour of Day Weighting **Edit** button. The **Hour of Day Weighting** editor will appear where you will see that the default value for all hours of the day is 1.0 (Figure 11.31). To specify that energy would only be generated from 8:00 a.m. to 5:00 p.m., change the value of 1.0 to 0.0 for hours 0000-0800 and 1700-2400 (Figure 11.32).

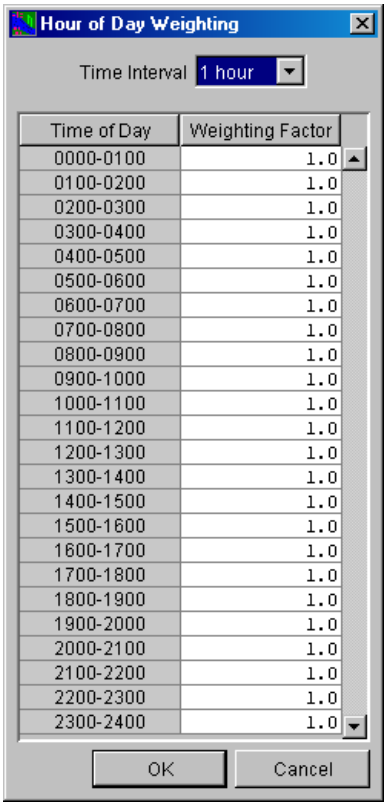

Figure 11.31 Hour of Day Weighting with Default Values of 1.0 Specified for Entire Day

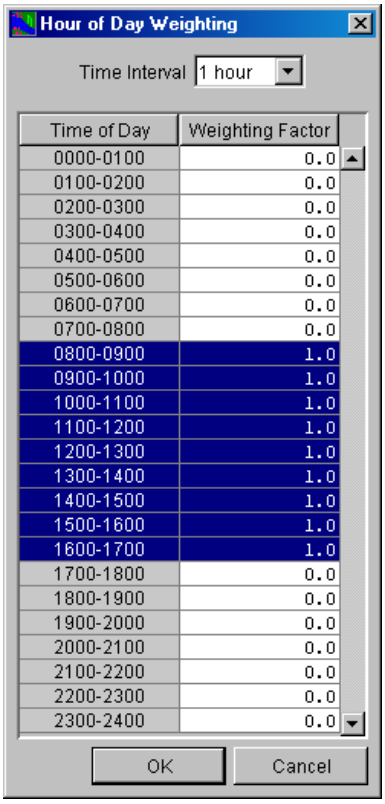

Figure 11.32 Hour of Day Weighting with Values of 1.0 Specified for Portion of Day

Basically, the values of 1.0 and 0.0 turn the hourly requirement "on" and "off", respectively (as previously shown in Figure 11.32). However, to indicate that the energy requirement between 10:00 a.m. and 1:00 p.m. is *twice* the energy requirements of the other hours (when energy is being generated), you would change the value of 1.0 to 2.0 for hours 1000-1300 (Figure 11.33).

Click **OK** to close the **Hour of Day Weighting** editor. In the hydropower rule editor, the check box in front of the Hour of Day Weighting will display a check mark, as shown in Figure 11.34 (only when the default set of weighting factors is modified).

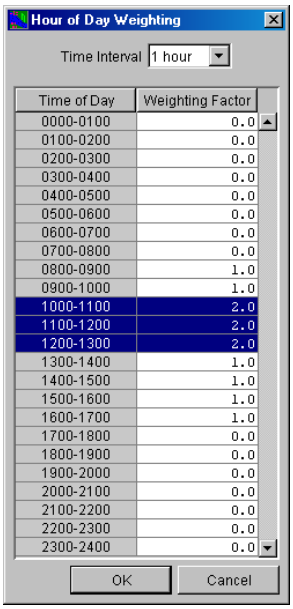

Figure 11.33 Hour of Day Weighting to "Double" the Power Requirement for Portion of Day

Figure 11.34 Hour of Day Weighting Modified from Default Values

11.5.9.5 Day of Week Weighting Factors

The Day of Week Weighting Factors allow you to specify a daily distribution of monthly energy requirements (see Section 11.5.9.1) based on the *day of the week*. For example, if you want the power plant to only generate during a portion of the week (e.g., during the work week), you can set the factor 1.0 for Monday-Friday and set it to 0.0 for Saturday and Sunday. To do this, click on the Day of Week Weighting **Edit** button. The **Day of Week Weighting** editor will appear where you will see that the default value for all days of the week is 1.0 (Figure 11.35). To specify that energy would only be generated Monday through Friday, change the value of 1.0 to 0.0 for Saturday and Sunday (Figure 11.36).

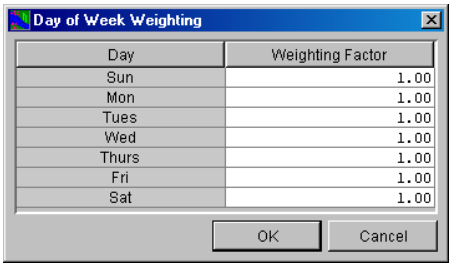

Figure 11.35 Day of Week Weighting with Default Values of 1.0 for Each Day of the Week

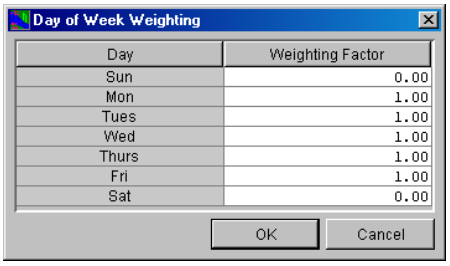

Figure 11.36 Day of Week Weighting with Values of 0.0 for Saturday and Sunday

Basically, the values of 1.0 and 0.0 turn the daily requirement "on" and "off", respectively (as previously shown in Figure 11.36). However, to indicate that the energy requirement on Wednesday is *twice* the energy requirements of the other days (when energy is being generated), you would change the value of 1.0 to 2.0 for Wednesday (Figure 11.37).

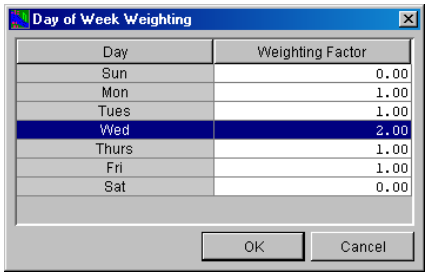

Figure 11.37 Day of Week Weighting to "Double" the Power Requirement on Wednesday

Click **OK** to close the **Day of Week Weighting** editor. In the hydropower rule editor, the check box in front of the Day of Week Weighting will display a check mark, as shown in Figure 11.38 (only when the default set of weighting factors is modified).

Figure 11.38 Day of Week Weighting Modified from Default Values

11.6 Common Options for Rule Definition

All of the function rules allow the specification of one or more options to modify the release requirement defined by the rule. These options can be used individually or in combination with one or more other options. The rule definition options are described below and include Interpolation Method, Hour of Day and Day of Week multipliers, Rising and Falling conditions, and Seasonal Variation.

11.6.1 Interpolation Method

Many of the rule types describe the release as a function of some variable (e.g., time, elevation, inflow, etc.). You will need to enter these functions in the form of a table where the values of the variable increase as you move down the table. You must indicate to the program how to determine values between those values explicitly entered in the table by selecting one of the following interpolation types (see Figure 11.39):

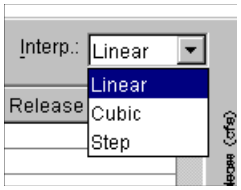

Figure 11.39 Interpolation Methods

- **Linear Interpolation** (Figure 11.40) means the table describes a curve drawn with straight lines. Values between those values entered in the table are linearly interpolated.

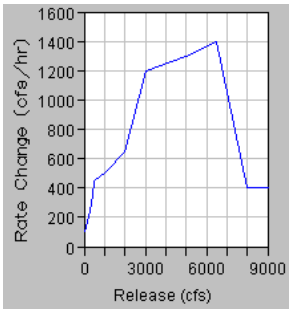

Figure 11.40 Linear Interpolation Method

- **Step Interpolation** (Figure 11.41) means that the table describes a step function, where the values in one row hold constant until changed by the next row.

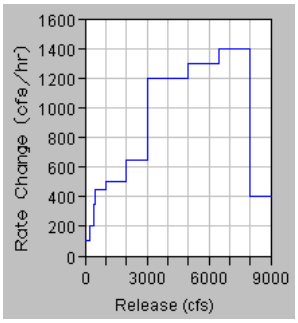

Figure 11.41 Step Interpolation Method

- **Cubic Interpolation** (Figure 11.42) will cause the program to interpret the table as a 3-point Cubic Spline curve. The interpolation between entered values is determined by the cubic spline function defined with each three consecutive rows in the table.

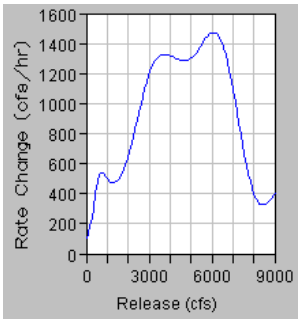

Figure 11.42 Cubic Interpolation Method

11.6.2 Hour of Day Multiplier

The Hour of Day Multiplier allows you to specify a factor (based on the *time of day*) that will be applied to the release specified by a rule. To do this, click on the Hour of Day Multiplier **Edit** button. The **Hour of Day Multiplier** editor will appear where you will see that the default value for all hours of the day is 1.0 (Figure 11.43). If you have a minimum release rule that requires a minimum flow only during a portion of the day, you can set the multiplier for those hours to 1.0 and set all other hours to 0.0. For example, to specify that a rule would only apply from 8:00 a.m. to 5:00 p.m., change the value of 1.0 to 0.0 for hours 0000-0800 and 1700-2400 (Figure 11.44). If you want to increase the minimum release by 50% between 1:00 p.m. and 3:00 p.m., then enter a factor of 1.5 for hours 1300-1500.

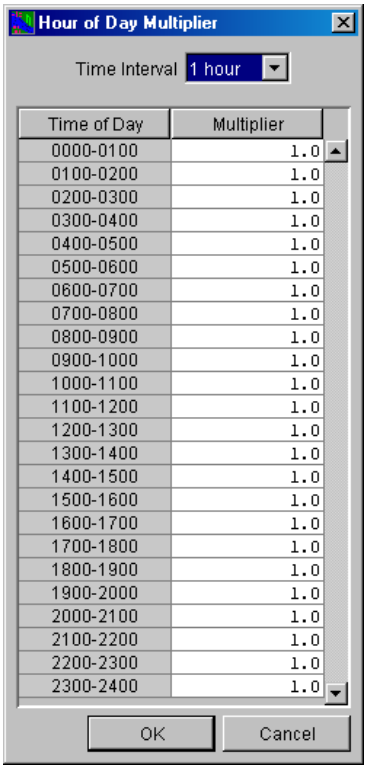

Figure 11.43 Hour of Day Multiplier with Default Values of 1.0 Specified for Entire Day

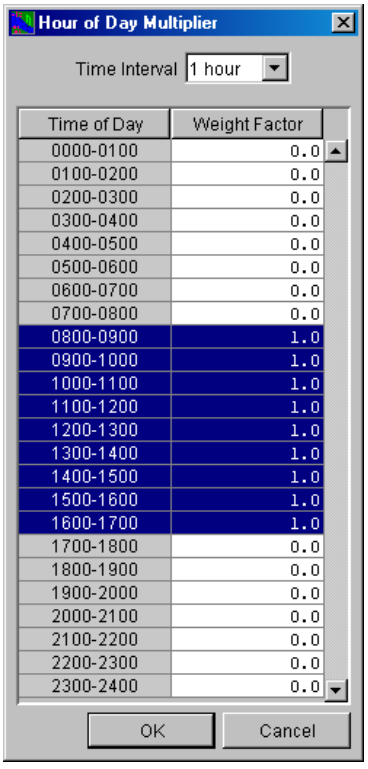

Figure 11.44 Hour of Day Multiplier with Values of 0.0 Specified for Portion of Day

Click **OK** to close the **Hour of Day Multiplier** editor. In the rule editor, the check box in front of the Hour of Day Multiplier will display a check mark (only when the default set of multipliers is modified, as shown in Figure 11.45).

Figure 11.45 Hour of Day Multiplier Modified from Default Values

11.6.3 Day of Week Multiplier

The Day of Week Multiplier allows you to specify a factor (based on the *day of the week*) that will be applied to the release determined by a rule. To do this, click on the Day of Week Multiplier **Edit** button.

The **Day of Week Multiplier** editor will appear (Figure 11.46) where you will see that the default value is 1.0 for all days of the week (Sunday through Saturday).

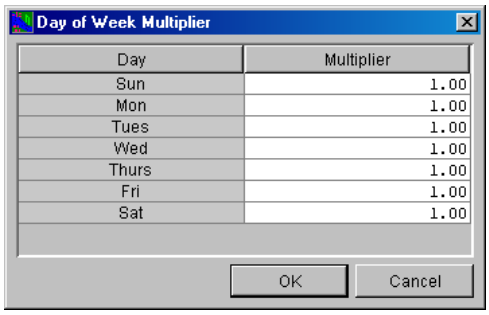

Figure 11.46 Day of Week Multiplier with Default Factors of 1.0 Specified for Each Day of the Week

If you have a minimum release rule that requires a minimum flow only during Monday through Friday, you can set the multiplier for Saturday and Sunday to 0.0 and leave all other days set to 1.0 (Figure 11.47).

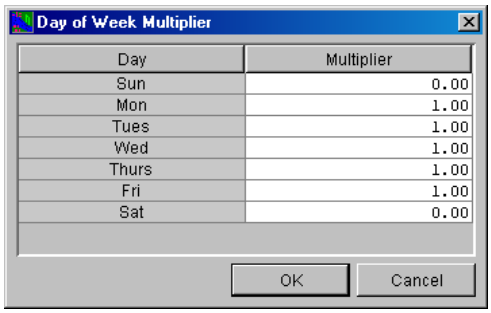

Figure 11.47 Day of Week Multiplier with Factors of 0.0 Specified for Saturday and Sunday

If you want to increase the minimum release by 50% on Wednesday, then enter a factor of 1.5 for Wednesday.

Click **OK** to close the **Day of Week Multiplier** editor. In the rule editor, the check box in front of Day of Week Multiplier will display a check mark (only when the default set of multipliers is modified, as shown in Figure 11.48).

Figure 11.48 Day of Week Multiplier Modified from Default Values

11.6.4 Rising / Falling Condition

The Rising/Falling Condition is a mechanism you can use to restrict the applicability of a rule. If, during a given decision interval, the specified condition is met, then ResSim evaluates the rule and applies it within the release determination logic. However, if the condition is not met, ResSim ignores the rule.

The Rising/Falling Condition option is available from many of the rule editors and allows you to select one of eight conditions with which you can restrict the applicability of a rule. These conditions include rising pool elevation, rising or constant pool elevation, falling pool elevation, falling or constant pool elevation, rising inflow, rising or constant inflow, falling inflow, or falling or constant inflow.

To apply a rising/falling condition to a rule:

1. Click the Rising/Falling Condition **Edit** button and the **Rising/Falling Condition** dialog box will open (Figure 11.49).
2. For the **Condition**, choose **Rising**, **Rising or Constant**, **Falling or Constant**, or **Falling** from the list.
3. For the **Parameter**, choose **Pool Elevation** or **Inflow** from the list.

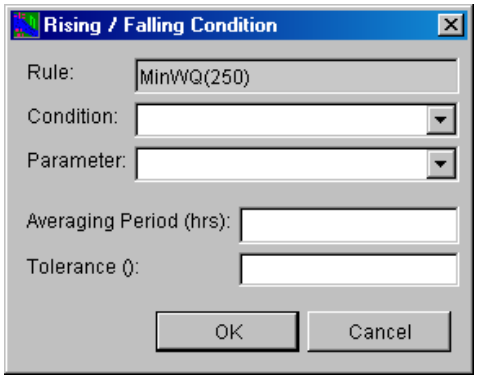

Figure 11.49 Rising / Falling Condition Dialog Box

4. Enter values for **Average Period** and **Tolerance**. These attributes help determine if the trend of the data meets the condition, rather than allowing a small deviation in the data to cause unstable or unexpected behavior.
5. Click **OK** to close the **Rising/Falling Conditions** dialog box. A check mark will appear in the Rising/Falling Conditions checkbox (as shown in Figure 11.50).

Figure 11.50 Rising / Falling Condition Modified from Default

11.6.5 Seasonal Variation

If your rule is a function of an internal (model) variable or an external variable (see Section 11.5.3), you can make your rule *seasonally varying* by using the **Seasonal Variation** option. For example, if the maximum flow allowed at a downstream control is described as a function of pool elevation and growing season, you would create a downstream control rule, make it a function of pool elevation, then select the Seasonal Variation **Edit** button from the rule editor. The **Seasonal Variation** editor will be displayed (Figure 11.51).

Enter the dates when the seasons change in the table. Each additional entry in the table will create an additional column in the function table on the main rule editor. Before clicking **OK**, be sure to select the interpolation type (see Section 11.6.1 for details on **Interpolation** methods). This will define how values will be determined between the seasonal columns describing the release function.

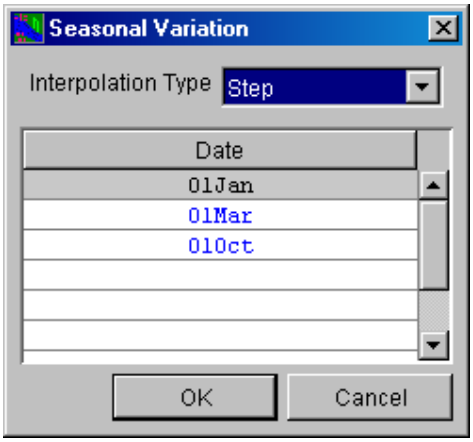

Figure 11.51 Seasonal Variation Dialog Box

11.7 Editing the Reservoir Decision Interval

By default, the reservoir makes a new release decision at every computation interval. The Reservoir Decision Interval Editor (Figure 11.52) allows you to specify a different decision interval (or schedule). By changing the decision interval, you can require the reservoir to evaluate conditions over a varying time horizon to determine its releases.

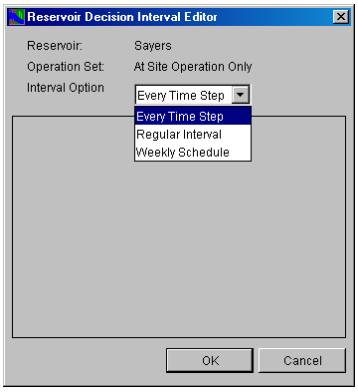

Figure 11.52 Reservoir Decision Interval Editor, Interval Options

To edit the reservoir decision interval:

1. Select **Decision Interval** from the **Operations** menu of the Reservoir Editor. The **Reservoir Decision Interval Editor** will open (Figure 11.52).
2. The name of the **Reservoir** and its **Operating Set** appear at the top of the editor.
3. Select an **Interval Option** from the list.
   - **Every Time Step** is the default.
   - **Regular Interval**
     Figure 11.53 allows you to specify the decision interval as some multiplier of the compute interval.
   - **Weekly Schedule**
     Figure 11.54 allows you to specify the days of the week and the hours of the day at which the reservoir can change the releases.

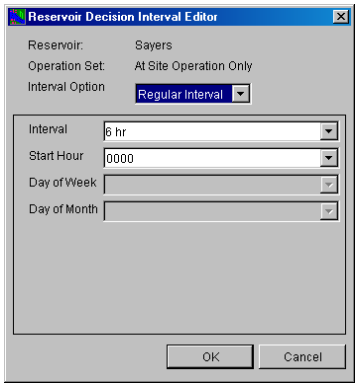

Figure 11.53 Reservoir Decision Interval Editor, Regular Interval Option

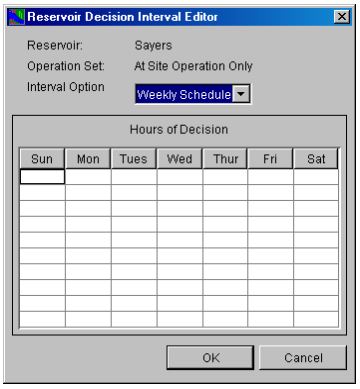

Figure 11.54 Reservoir Decision Interval Editor, Weekly Schedule Option

4. Click **OK** to close the editor.

11.8 Selecting the Reservoir Guide Curve

The top of zone curve of any zone in your reservoir can be selected to represent the Guide Curve (i.e., target elevation) of your reservoir. The Guide Curve (or rule curve) represents the basic objective of the reservoir − get the pool elevation to, and hold it at, the Guide Curve. Without any other operational constraints, the decision logic will attempt to get to and keep the reservoir at the Guide Curve, within maximum outlet capacity and physical rate of change constraints. By *default*, the zone initially labeled *Conservation* is selected as the Guide Curve. To select a different zone to represent the Guide Curve for your reservoir operation set:

1. Select **Guide Curve** from the **Operations** menu of the Reservoir Editor (Figure 11.55). The **Reservoir Guide Curve Editor** will open (Figure 11.56). The top portion of the editor is used for selecting the Guide Curve Zone while the bottom portion of the editor is used for defining Credit Storage for Flood Control (described in Section 11.9).

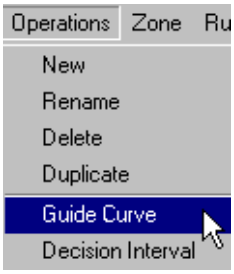

Figure 11.55 Operations Menu, Guide Curve Option

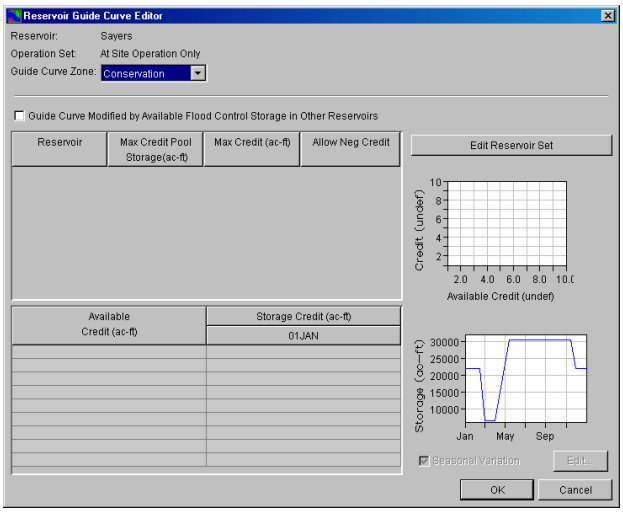

Figure 11.56 Reservoir Guide Curve Editor

2. Select a zone from the **Guide Curve Zone** list. The guide curve zone list includes all of the reservoir's zones in the current operation set and an option named **None**. Selecting the None option is equivalent to selecting the Inactive zone -- it will cause the reservoir to remain empty unless the rules in the zones cause the reservoir to store water for a period of time.

11.9 Adjusting the Guide Curve for Flood Control Credit Storage

In the previous section (Section 11.8), we learned that the Reservoir Guide Curve editor allows you to pick the top of zone curve for any zone in your operation set to act as the guide curve. This editor also allows you to identify reservoirs available to provide **Flood Control Credit Storage** to the current reservoir. What this means is that if flood control space is available in other reservoirs, then the required flood control space in the current reservoir can be reduced. You can think of this as raising the Guide Curve at the current reservoir.

To define the reservoirs providing storage credit and the available flood control space in each reservoir that is used for credit:

1. Select **Guide Curve** from the **Operations** menu of the Reservoir Editor (as previously shown in Figure 11.55). The **Reservoir Guide Curve Editor** will open (as previously shown in Figure 11.56).
2. Click in the check box labeled **Guide Curve Modified by Available Flood Control Storage in Other Reservoirs** (Figure 11.57).

Figure 11.57 Reservoir Guide Curve Editor, Checkbox to Indicate Guide Curve is Modified by Available Flood Control Storage in Other Reservoirs

3. Select the **Edit Reservoir Set** 

button to access a dialog box that allows you to choose from a list of available reservoirs.
4. In the **Available** list, click on the name of the reservoir(s) you want to use for flood control storage credit (Figure 11.58), then click **Add** to move it to the **Selected** list. Click **OK** to close the selection dialog box.

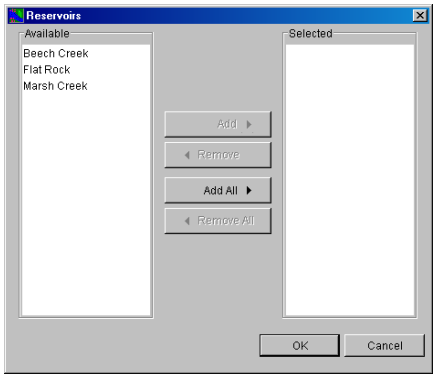

Figure 11.58 Reservoir Guide Curve Editor, Edit Reservoir Set to Select Reservoirs to Provide Flood Control Storage Credit

5. The reservoir(s) selected to provide flood control storage credit are shown in the upper table of the Reservoir Guide Curve editor (Figure 11.59). For each reservoir in the upper table, define the **Maximum Credit Pool Storage** (typically, near the storage at the top of the flood pool) and the **Maximum Credit** that the reservoir can provide. You will also need to determine if each reservoir can provide "negative" credit. Negative credit from a credit reservoir would have the effect of lowering the guide curve at the reservoir where you are defining the guide curve. This could occur if the computed storage in the credit reservoir's pool is greater than its maximum credit pool storage.

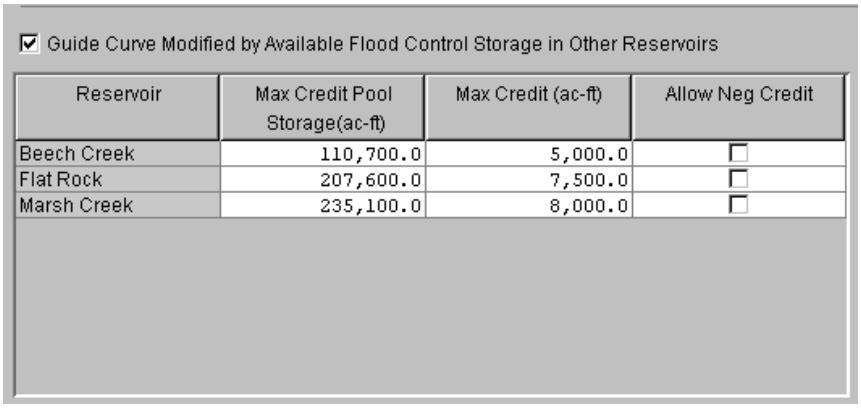

Figure 11.59 Reservoir Guide Curve Editor, Reservoirs to Provide Flood Control Storage Credit

6. Next, in the lower table of the Reservoir Guide Curve editor (Figure 11.60), define the credit storage that can be used at the current reservoir as a function of the total maximum credit storage provided by those reservoirs listed in the upper table. This can be defined by a single curve or by a seasonally varying family of curves. See Section 11.6.5 for details on the **Seasonal Variation** option.

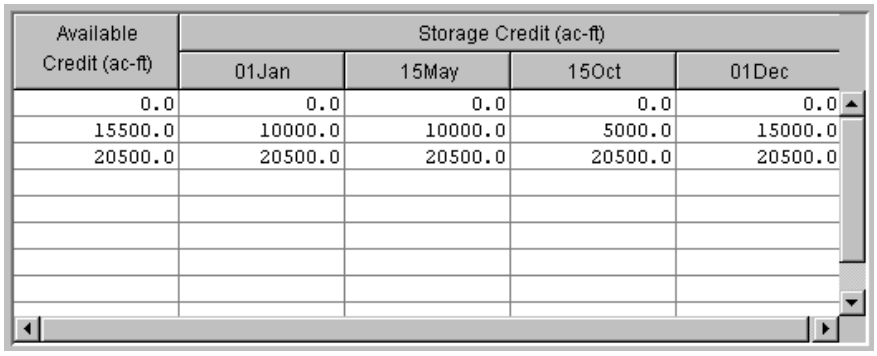

Figure 11.60 Reservoir Guide Curve Editor, Definition of Function for Using Flood Control Storage Credit

Figure 11.61 shows an example of the Reservoir Guide Curve Editor where Flood Control Storage Credit is defined for a reservoir (Sayers) using credit storage from three reservoirs (Beech Creek, Flat Rock, and Marsh Creek).

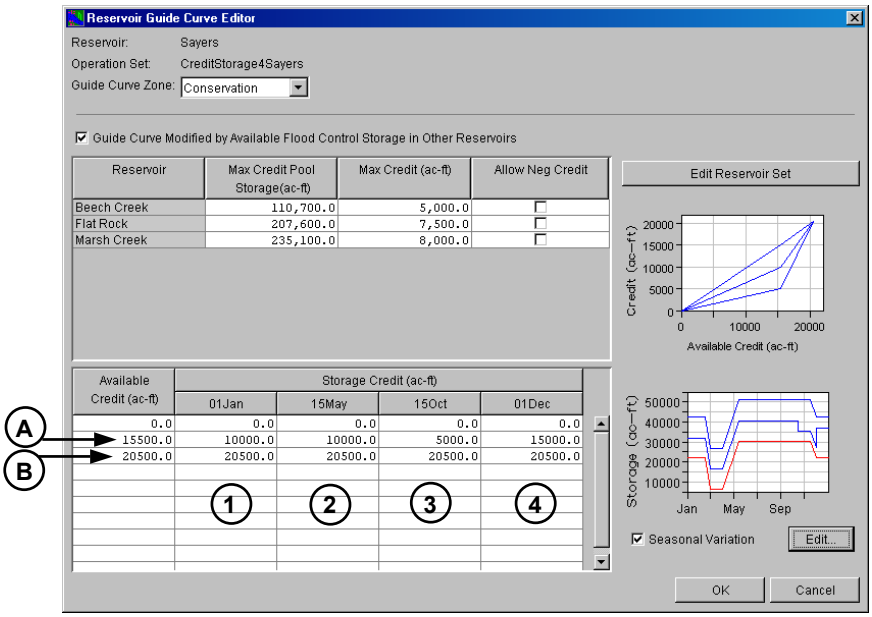

Figure 11.61 Example of Reservoir Guide Curve Editor Showing Definition of Flood Control Storage Credit

On the right side of the editor, there are two mini-plots that are associated with data in the lower table of the editor. The top mini-plot (Credit vs. Available Credit) shows the storage credit values as a function of available credit in the other reservoirs. Figure 11.62 illustrates the top mini-plot along with cross-reference numbers that refer to the four seasonal columns in the lower table of the editor. The bottom mini-plot displays the *regular* Guide Curve (in red) along with the adjusted Guide Curve(s) based on the potential credit storage to be used (seasonally, in this example). Figure 11.63 illustrates the bottom mini-plot along with cross-reference letters that refer to the rows in the lower table of the editor. These mini-plots can be viewed in full size when you double click on them.

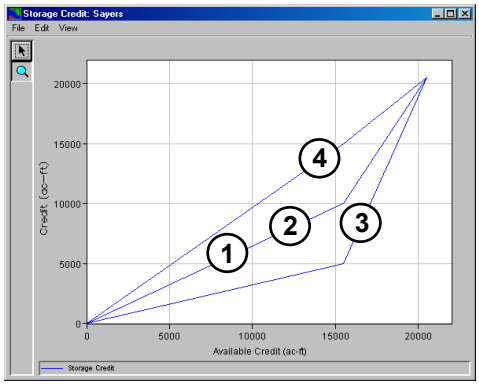

Figure 11.62 Reservoir Guide Curve Editor, Available Credit Storage vs. Credit Storage

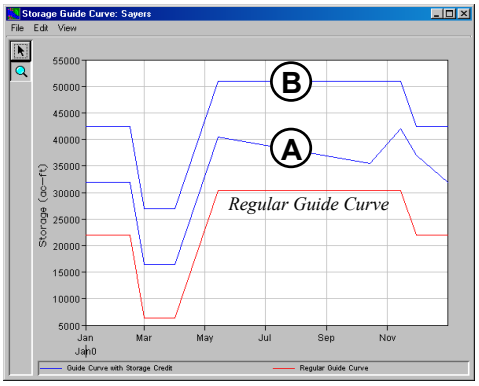

Figure 11.63 Reservoir Guide Curve Editor, Seasonal Guide Curves for Potential Credit Storage